SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MAY, 1921.

GENERAL PHYSICS.

757. *Direct Reading Ultra-Micrometer.* **J. J. Dowling.** (Roy. Dublin Soc., Proc. 16. pp. 185–188, March, 1921.)—In a previous paper [Abs. 719 (1921)] a description was given of a valve method for measuring capacity, which could be applied to the measurement of extremely small displacements. The present paper describes improvements in the apparatus which render it more stable and reliable. A. W.

758. *Measurement of Small Angular Movements.* **A. Pflüger.** (Phys. Zeits. 22. p. 73, Feb. 1, 1921.)—The valve method here described is similar in principle to that of Whiddington [Abs. 1350 (1920)]. A condenser is used consisting of a fixed plate and a movable plate capable of rotation about an axis coincident with one edge. The plates initially are parallel. This condenser forms part of the oscillatory circuit of a valve generator, and any variations of capacity due to small angular movements of the movable plate are detected by a heterodyne method. The calculation of the angular movement is based on the work of Pungs and Preuner [Abs. 618 (1920)]. A. W.

759. *Limitations of the Stop-Watch as a Precision Instrument.* **A. L. Ellis.** (Am. I.E.E., J. 40. pp. 104–112, Feb., 1921.)—A description, with numerous diagrams, is given of the start and stop mechanism of a number of different makes and types of stop-watch. These are discussed, and it is concluded that, due to inherent errors of timing train, and those due to mechanical limitations and design, practically nothing is gained in accuracy by increasing the number of jewels beyond the standard seven-jewel movement. Some of the larger errors do not follow the law of probability, for while the errors may be either plus or minus, and vary somewhat in magnitude, some at least depend on the interval of time being measured, as for instance in the case of the "Jockey Club" type of stop-watch, if the interval being timed is less than 30 seconds, the hand will jump forward upon being started again; if the interval is more than 35 seconds the hand will jump backward on starting again. The sources of error in a watch are such that at least two watches should be used simultaneously for timing an event, timing intervals of varying length if possible, the mean of all observations to be taken. The stop-watch applied to engineering measurements, as for instance the calibration of watt-hour meters, is not sufficiently robust for the purpose, and it is hoped that manufacturers will make an effort to produce a stop-watch suitable for this class of service. A. W.

760. *The Statistical Methods of Physics and the "Probability After-Effect."* **R. Fürth.** (Phys. Zeits. 21. pp. 582–588, Nov. 1 and 15, 1920. Paper read before the 86. Naturforscherversamml., Nauheim, Sept., 1920.)—To each microscopic state of a system—indicating the totality of the conditions of the individual bricks by the statement of all the microscopic parameters which, taken singly, determine those conditions—may be coordinated a macroscopic state indicating the totality of a series of properties; but a macroscopic state may correspond to a large number of microscopic states. The question then arises, how it is that we may apply statistical methods to molecular phenomena, though we believe that these phenomena are not accidental, but determined in some definite sense. The author discusses this question with respect to Galton's board (bagatelle). A ball rolling down the board will be deflected to the right or the left by the pins which it hits, and the probability of the deflection is determinable by the error function of Gauss. But a ball might secondly happen to hit a pin normally while at rotational velocity zero; it might or might not then come to rest (inelastic or elastic impact). The pin would thus become a point where the paths diverge, certain directions being impossible. The second case, discussed by R. v. Mises (*ibid.*, 21. p. 225, 1920), is mechanically impossible, however, and can only be approached with respect to the Brownian movements and to the momentary density of the traffic in a street. Smoluchowski (*ibid.*, 19. p. 421, 1918, and 20. p. 21, 1919; Wien. Ber. 123. p. 2389, 1914) suggested that we can make calculations if we know the previous history of the system as to the direction of motion or the density distribution (his "Wahrscheinlichkeit-Nachwirkung"). Even in the absence of such knowledge assumptions as to this after-effect may be helpful. H. B.

761. *Extension of Heaviside Principle to Operator Functions.* **A. Press.** (Electrician, 86. pp. 349–350, March 25, 1921.)—It is assumed that developments valid in ordinary algebra true for n have a corresponding symbolic counterpart in the Heaviside generalised algebra, without regard to computational significances, based upon n being taken as positive, negative, fractional, or otherwise. The two algebras will then appear to be overlapping, as it were, with n taken in a certain way only. As an example of such symbolic correspondence is taken the formula $d^n(x^m)/dx^n = (\underline{m}/\underline{m-n})x^{m-n}$. In ordinary algebra n must at least be integral. By correspondence in the generalised algebra of pure symbolism, totally irrespective of computational reference, it is assumed that the formula holds whether n is integral, fractional, positive or negative, etc. Following similar lines a new generalised development of unity may be obtained which can be used to explain and clarify much of the work of Heaviside on the generalised development of the exponential Bessel's functions, etc. A. W.

762. *The Gyroscopic Compass in Shaft-Sinking; Apparatus serving to Reduce the Number of Bore-Holes required.* **O. Martienssen.** (Elekt. Zeits. 41. pp. 462–466, June 17, 1920. Paper read before the Elekt. Verein, Oct. 28, 1919.)—Although deep-lying coal is better than that at shallow depths, it has hitherto been almost impossible to sink shafts in water-bearing mountainous regions to depths greater than 400 m. The method of sinking a shaft by freezing a ring of ground with the aid of a freezing mixture passed down the bore-holes is now well-known, but even here it is important that the bore-holes for this purpose should be as few in number as is possible, on account of the expense. There has, however, hitherto been no method by which it could be secured that the long drill rods should maintain their exact direction, and not deviate from the desired course. The condition necessary for a complete ring of frozen ground is that no bore-hole shall be more than 2 m. distant from the adjacent bore-hole. If this be fulfilled, the freezing liquid in the bore-holes, circulated at − 25° C., will, in six months, freeze solid a column of 2½ m. diameter around the bore-hole; and, given the above condition as regards spacing, a solid ring of frozen ground 2 m. in thickness will be obtained. Diagrams are given in the article which show that, employing the drill rod without any correcting arrangement, out of 37 bore-holes drilled 13 were useless owing to their having departed either too far to the outside or else penetrated within the hole, while 5 openings were left in the ring, which would require at least 5 more bore-holes to be sunk in order to complete the ring.

New Apparatus.—The new gyroscopic inclinometer apparatus devised by the Gesellschaft für Nautische Instrumente enables the sinking of the drill rod to be carried out under accurate control of its direction, and its use has enabled a ring of bore-holes to be drilled down to 328 m. depth with only 19 bore-holes, which means a great saving of expense. The apparatus, which is fully illustrated and described, comprises a hollow casing (containing the inclinometer arrangements) which, by means of end brushes accurately fits the bore-hole interior. This casing is lowered by means of a rope, and measurements are taken every 2 m. of depth. The casing contains two pendulums which can record, on a strip, any displacement from the vertical, and beneath the recording apparatus is a small gyroscopic compass which is run at 25,000 r.p.m. by means of an electric motor. The compass itself has insufficient directive force to move the measuring apparatus round, but effects it through a small servo-motor attachment so that the inclinometer is always definitely oriented with respect to the gyro compass, and hence with respect to the meridian. One pendulum is made an E.–W. pendulum, whilst the other is a N.–S. pendulum. It thus follows that the deviation marked by the pendulums can be converted into absolute deviation from the vertical. By the use of this apparatus it is possible to correct any bore-hole which may have departed from its course, and also to supply an additional bore-hole at any spot where the circle of bore-holes is incomplete. It is stated that the manipulation is such that trained operators are required; hence the makers do not sell the apparatus outright, but send it together with the skilled staff to the scene of operations. For further details the original article should be referred to. L. H. W.

763. *Roughness and Critical Number; Experimental Contribution to the Turbulence Problem.* **L. Schiller.** (Zeits. f. Physik, 3. 5. pp. 412–416, 1920.)—In recent theoretical literature on the turbulence problem [see Abs. 20 (1920)], the condition of the boundary wall, with its less or greater roughness, a quality present in a technically smooth tube, is shown to play an important part in the generation of turbulence. Reference is made by the present author to the work of v. Mises, after which he raises the question as to whether the roughness of technically smooth tubes is sufficient to produce the effects observed, *i.e.*, whether the boundary condition is necessary for the presence of turbulence or not. Experiments are described for the solution of this problem. The initial condition of the entering water is shown to be of greater importance than the roughness of the boundary wall. No previous experiment could be found, free from objection, to give a dependence of the critical number for tubulence on the boundary condition of technically smooth tubes. The author has now experimented with a tube purposely made rough, and has determined its critical numbers for turbulence. He finds that for the occurrence of turbulence, one rough place is sufficient and that persistent turbulence does not require a continuous rough boundary. The place causing the greatest disturbance is therefore the only one which comes into account, and determines the critical number. H. H. Ho.

764. *"Flow" of Metal Wires under Overload.* **P. Ritter.** (Phys. Zeits. 22. pp. 53–59, Jan. 15, 1921.)—The flow of metal wires, when overloaded beyond the elastic limit, was first investigated for various specimens of copper, and the results are exhibited in a series of curves showing the time variations of the effect with different overloads. Aluminium, zinc, and lead exhibit similar phenomena to copper, while iron, brass, and bronze possess different characteristics. A. W.

765. *Flow of Viscous Fluids through Orifices.* **W. J. Walker.** (Phil. Mag. 41. pp. 286–288, Feb., 1921.)—Shows that the discharge of a viscous fluid through an orifice may actually be greater, under otherwise similar conditions, than that of a non-viscous one. Meter coefficients calculated on the basis of the equation of resistance to fluid motion on which the above paradoxical result is based, agree with those obtained experimentally.

J. W. T. W.

766. *Determination of Absolute Viscosity by the Gümbel Viscometer.* **L. Schiller.** (Zeits. techn. Physik, 2. 2. pp. 50–52, 1921.)—Gümbel has recently [see Abs. 226B (1921)] described a new viscometer for the determination of absolute viscosity. The apparatus consists essentially of a vessel with circular aperture in the centre of the base and a concentric circular disc at a small distance from the aperture. The outflow ensues around the circumference of this disc, and then runs radially between this and the base to the exit. The principal loss in pressure by internal friction then takes place in the narrow space between the two plane plates, flow and discharge ensuing through two concentric circular cylindrical mantles. Gümbel, without derivation or statement submits the following expression for arriving at the viscosity : $Q = H_{\text{mean}} . \gamma . \pi h^3 . \log_e (R/r)/6\eta$, where Q is the outflow in m.³ per sec., r the inner radius of the inserted disc, R the external radius, h the aperture width in m., H the liquid height in m., γ the weight per unit vol. (in kg./m.³), and η the viscosity coefficient in kg. sec./m.². The present author now shows that by accepting Gümbel's assumptions an expression for the viscosity is obtained which deviates in two respects from that given by Gümbel, namely :

$$\eta = \left[(H - 0{\cdot}8854^2) \times 10^{-8}(Q/(h - h')^2\right]\left[\{(h \times h')^3 \times 0{\cdot}5328^3\}/Q\right].$$

The author states that for the determination of absolute viscosity it is necessary to develop further the theory of the apparatus, and to experiment with liquids of greatly differing viscosities. A comparison is made between Engler's viscometer and Gümbel's, greatly in favour of the former whose theory is stated to be much more rigidly established. H. H. Ho.

767. *Effect of Wind and Air Density on the Flight of Projectiles.* **K. Schwarzschild.** (Preuss. Akad. Wiss. Berlin, Ber. 1. pp. 37–63, 1920.)—Formulæ are derived theoretically for the effect of wind and variations in the density of the air in producing deviations in the path described by projectiles. Numerical examples are given. A. W.

768. *Soaring Flight.* **E. H. Hankin,** with introduction by **F. Handley Page.** (Cambridge Phil. Soc., Proc. 20. pp. 219–227, Jan., 1921.)—Discusses in turn the various possible explanations of the soaring flight of birds and insects, namely, that it is due to undiscovered wing movements, to lateral gusts, to ascending currents of air, or to turbulent motion in the air. The author concludes that none of these fits in with the observed facts as regards soaring flight, but that, in some at present unexplained manner, the energy involved in soaring flight at slow speed is derived from the sun's rays. J. W. T. W.

769. *Energy Laws.* **A. Schack.** (Phys. Zeits. 22. pp. 73–75, Feb. 1, 1921.)—A theoretical discussion of atomic energy, based on the second law of thermodynamics. A. W.

770. *Constitution of Atoms.* **O. Masson.** (Phil. Mag. 41. pp. 281–285, Feb., 1921.)—The author proposes to name the "positive nucleus" baron (βάρος, weight), whilst retaining "electron" for the negatively charged particle. The baron is symbolised b, whilst e is still used for the electron. Thus in his paper he uses—

b = one baron (charge + 1, mass 1),
e = one electron (charge − 1, mass negligible).

"A" may stand for the mass of any elementary atom with the atomic number N,

As an example we may quote :—

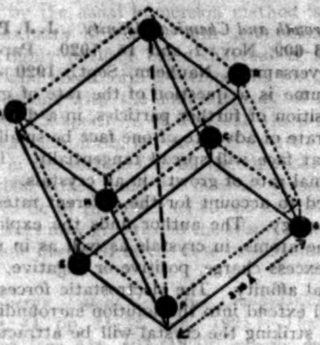
If we write $A - 2N = n$, we find from Aston's work that $n = 0$ in pure elements, He, C, N, O, S, and also in the lower isotopes of B, Ne, Si, Ar, Li, Mg, Ca, and perhaps some of the other light atoms. It follows therefore that the group (b_2e) may be regarded as a secondary unit of positive charge, with mass 2, and that $(b_2e)N$ expresses the composition of the nucleus of any of those atoms. A. B. W.

771. *The Structure of Atoms and Molecules; Old and New Theories.* **I. Traube.** (Phys. Zeits. 21. pp. 592–597, Nov. 1 and 15, 1920. Paper read before the 86. Naturforscherversamml., Nauheim, Sept., 1920.)—The author points out that his overlooked papers of the period 1892 to 1910 embody modern views. He starts from the assumption that the molecular volume m/d is not simply the sum of the atomic volumes, but composes also the co-volume ϕ which is the $(v - b)$ of van der Waals. His third volume is the Lorenz-Lorentz constant $(n^2 - 1)/(n^2 + 2) \cdot 1/d$ which he calls the nucleus volume. In this latter is contained that portion of the space taken up by the internal electrons which remains impenetrable in atomic collisions. For liquids of various types the ratio: Molecular refraction/Sum of chemical valencies, is constant, and in the carbon compounds of H, O, N, F, Cl, P, B, Si, the atomic refractions are in the proportions 1 : 2 : 3 : 4 : 5 : 7. The number of valency-electrons (or valons) approximately determines the space occupied by the atom, and the number of the valons is equal to the square root of the atomic weight. According to Kossel the volume of the ions determines the magnitude of the affinities, equal numbers of valons presumed. The author would rather say that the magnitude of the affinity determines the size of the atomic volume. Cohesion and electric forces are also discussed. H. B.

772. *The Possible Existence of Binding Rings in Diamond; Confirmation of Debye and Scherrer's Conclusion.* **N. H. Kolkmeijer.** (K. Akad. Amsterdam, Proc. 23. 1. pp. 120–128, 1920.)—Debye and Scherrer [Abs. 128 (1919)] investigated whether the assumption of the existence of "binding rings" of electrons between the carbon atoms in diamond, was in accordance with the intensities of X-ray spectra reflected from certain planes of the diamond lattice as worked out by Bragg. They concluded that binding rings did not exist in diamond. The author has further investigated this point and has arrived at the same conclusion. E. A. O.

773. *Cohesion Forces of the Diamond.* **H. Thirring.** (Zeits. f. Physik, 4. 1. pp. 1–25, 1921.)—Assuming with Kossel that the diamond possesses the simplest atomic structure of all the bodies the crystal lattice and macroscopic symmetry of which are known, the author investigates how the electrostatic forces of the C-atoms and of their electrons after Born and Landé [Abs. 528 (1919)] can account for the cohesion of the lattice. There seem to be only two possibilities: A, the valency electrons describe orbits in planes half way between two adjacent nuclei as in the homopolar hydrogen molecule of Bohr and Debye in Haber's lattice model of the monovalent metals; but the Bohr-Debye molecule has been abandoned, and none of the other suggestions has led to satisfactory structures. B, the ring systems of the electrons of homopolar atomic compounds have the same order of magnitude as in the free atoms of the constituents, and there is no exchange of electrons. On that assumption it is difficult to understand any attraction between neutral atoms, except when the tetrahedra of diamond are so oriented that the apex of direction is normal to the face of a neighbouring atom; but quantitative considerations show that B is impossible. Thus both A and B seem to fail. But Coster has pointed out that the objections to A of Debye and Scherrer hold only for very small ring radii. The author shows mathematically that in heteropolar as well as in homopolar substances linkage and cohesion depend upon the valency electrons, but there is a difference between the two cases. In the heteropolar compounds the atoms of the constituents pass, by an exchange of electrons, into the stable condition of the inert gases and turn into ions (Kossel and Born); from the ions is formed, in the sublimation, a lattice which is alternately set with ions of both signs, the equilibrium depending upon both the attractive forces of opposite excess charges of the nuclei and the repulsion between the external shells of electrons. In the homopolar compounds and in solid elements there is no exchange of valency electrons, but these electrons are split off and describe orbits between the nuclei; they form complexes which represent the independent negative bricks of the lattice, the residual atoms representing the positive bricks. **H. B.**

774. *The Crystalline Structure of Antimony.* R. W. James and N. Tunstall. (Phil. Mag. 40. pp. 233–239, Aug., 1920.)—From an examination of the crystalline structure of antimony carried out by W. H. and W. L. Bragg [Abs. 87 (1914)] it was concluded that the arrangement of the atoms in antimony was similar to that in diamond, except that the whole structure was distorted along the trigonal axis. The observations on which this conclusion was based were incomplete, however, and it was desirable to make a more detailed examination of the structure. The results now obtained show that a structure similar to that of diamond will not explain the spectra observed from the various faces. The structure found for antimony now consists, as in the diamond, of two interpenetrating face-centred lattices, but the arrangement of the lattices is different in the two cases. The structure is shown in the diagram, in which for the sake of clearness only one of the small cubes is shown. Suppose for one of the lattices, diagonals are drawn parallel to the trigonal axis in each of the eight equal rhombohedral cells into which the unit lattice may be divided. From considerations of symmetry it will be seen that the atoms of the second lattice must lie on these diagonals. If they lay at the unoccupied corners of the first lattice the structure would become a simple rhombohedral one. This will not fit in with the observed facts, but if the atoms of the second lattice are all displaced from these corners along the diagonal in the same direction by a distance equal to 0·074 of the length of a diagonal of one of the small cells, all the observed facts are explained.



The distance between the centres of two atoms such as A and B in the close pair of planes, which is the closest distance of approach of two antimony atoms, is 2·87 Å., with a probable error of ± 0·01 Å. This can perhaps be considered the atomic diameter of antimony. For the wide pair of planes the closest distance of approach of two atomic centres such as B and E is 3·37 Å. The planes thus occur in pairs in which the atoms approach one another closely, the pairs being separated by a wider spacing. The very good cleavage of antimony is parallel to these pairs of planes. **E. A. O.**

775. *Nature of Crystal Cleavage.* **G. Wulff.** (Phys. Zeits. 21. pp. 718–720, Dec. 1 and 15, 1920. Paper read before the 86. Naturforscher-versamml., Nauheim, Sept., 1920.)—The cleavage of crystals along certain planes is one of the most striking and yet one of the least studied properties of crystals. It is now known that the exterior surfaces, or cleavage planes, are indicative of the internal structure of the crystal. As a result of the work of W. H. Bragg and W. L. Bragg, it is known also that the "element" of crystal structure is the simple atom, and not the molecule or atom-complex. From this knowledge it is possible to theorise relating to the forces of cohesion and other properties of the atoms in crystals. Thus the property of cleavage can be studied from this standpoint, the chemical affinities and forces of cohesion in different directions being deduced from the atomic structure of the crystal, as indicated by Bragg's X-ray analysis.

The author considers the individual cases of cleavage in crystals of fluorspar, zincblende, diamond, rocksalt, calcspar, and sulphur.

A. B. W.

776. *Crystal Growth and Chemical Affinity.* **J. J. P. Valeton.** (Phys. Zeits. 21. pp. 606–609, Nov. 1 and 15, 1920. Paper read before the 86. Natursforscherversamml., Nauheim, Sept., 1920.)—The shape which a crystal will assume is a question of the rate of growth. Every face advances by deposition of further particles, in a direction normal to the face; if then this rate of advance of one face be smaller than that of the adjacent faces, that face will spread tangentially. There will be a few directions of minimal rate of growth in all crystals. P. Curie and, later, G. Wulff attempted to account for the different rates by a tendency to minimal surface energy. The author finds the explanation in Kossel's hypothesis that the atoms, in crystals as well as in undissociated molecules, possess an excess charge, positive or negative, by virtue of which they show chemical affinity. The electrostatic forces of the ions of the external layers will extend into the solution surrounding a crystal. Ions in thermal motion striking the crystal will be attracted or repelled, and may be retained or may release and eject already solid particles. The orientation is decisive for these effects. If we imagine the face of a NaCl cube represented by a chess-board, with a + charge in the centre of a black square, and a − charge in each white square, half of the ions will on average be attracted, the other half repelled. Of those attracted only a few will be retained, because they may hit the centre or some other part of a square, near the edges of which the fields will neutralise one another. With this regular grouping of the charges the cubic face will hence grow slowly and will predominate. It will be different for the octohedral planes, alternately of Na and Cl ions. If the surface happens at one moment to consist of Na, all the Cl will be attracted, and they will settle midway between the Na; this face would grow very fast, and for that reason it does not develop and is unknown in NaCl. Gross objected that, on this view, rate of growth and rate of dissociation should follow the same law. The one is not the converse of the other, however; dissolution faces may be obtained curved or plane, whilst the growth proceeds always by plane faces.

H. B.

777. *Crystal Structure of Ice from its X-ray Pattern.* **D. M. Dennison.** (Phys. Rev. 17. pp. 20–22, Jan., 1921. Chem. News, 122. pp. 54–55,

Feb. 4, 1921.)—A small sample of ice composed of minute crystals gave by Hull's method a pattern of 12 clearly defined lines whose positions indicate that the lattice of an ice crystal corresponds to a hexagonal close-packed arrangement of molecules, consisting of two sets of interpenetrating triangular prisms with sides 4·52 Å. and height 7·32 Å. Since for close-packed spheres the axial ratio should be 1·633 instead of 1·62, the ice molecules act like spheres which have become flattened by 0·8 % in the direction of the hexagonal axis. This lattice is practically the same as that found for magnesium, but the differences in relative intensity between the lines of the two X-ray patterns suggest that ice molecules and Mg atoms must differ considerably in shape.

Molecular Formula for Ice.—From the density of ice and the dimensions of the lattice it follows that the formula for an ice molecule is $(H_2O)_2$ or H_4O_2. AUTHOR.

778. *Forces in Surface Films.* **A. M. Williams.** (Roy. Soc., Proc. 98. pp. 223–234, Dec. 3, 1920.)—The determination of the density of a finely-divided solid by the usual immersion method is used to illustrate the effects of accessibility of surface and adsorption on the apparent specific volume. Highly purified blood-charcoal is used as a suitable example and water and chloroform are employed for immersion. Observations are in agreement with the simple theory of these effects. The true specific volume of a specimen of charcoal which appears to be 0·51 in water and 0·46 in chloroform, is evaluated as 0·67 cm.^{3} per gm. The attractive pressure in the surface film on the charcoal is calculated to be of the order of 10,000 atmos., and the internal pressure of the charcoal itself is estimated to be of the order of 50,000 atmos. It is shown that such compressive forces may give rise in the adsorption layer to a diffusion p.d. of the magnitude observed in the case of suspensoids. A. B. C. L.

779. *Surface Energy, Latent Heat, and Compressibility.* **D. L. Hammick.** (Phil. Mag. 41. pp. 21–32, Jan., 1921.)—The paper consists of a further investigation [see Abs. 403 (1920)], chiefly mathematical, of the relation between surface energy and cohesion. The formulæ arrived at are tested against experimental data derived from various sources, tables being given for 11 organic liquids. Lewis's empirical approximation, that heat of compression is very nearly equal to latent heat of vaporisation per unit volume at 0° C., is deduced. The approximate constancy of the product of compressibility and surface energy at 0° C. is deduced, and the observed lack of constancy at other temperatures accounted for.
A. B. C. L.

780. *Surface Energy of Mercury and Energy Relations at the Interface between Mercury and other Liquids.* **W. D. Harkins** and **W. W. Ewing.** (Am. Chem. Soc., J. 42. pp. 2539–2547, Dec., 1920.)—Measurements have been made of the surface tension of mercury in a vacuum at temperatures between 0° and 60° by the drop-weight method, and of the interfacial surface tension between mercury and various liquids and vapours at 20° and with some liquids at different temperatures between 0° and 60°. The results obtained, together with those given in the preceding paper (*ibid.*, 2534–2538), indicate that the adhesional work between a mercury surface and the surface of an organic liquid is always greater than that between the organic liquid and water and also greater than that between the organic liquid and itself or the cohesional surface work. Further, for about one-half of the substances investigated, the difference between the adhesional work against mercury and that against water is nearly constant, namely 80–90 ergs; this is true for such liquids as the paraffin hydrocarbons, benzene, toluene, the xylenes, carbon tetrachloride, chloroform, and nitrobenzene, so that the work of attraction is by no means specific. On the other hand, the adhesional work is specifically high towards water in the case of the alcohols, water itself, organic acids, acetone, and ether, whilst that towards mercury is very high in the case of compounds containing iodine, bromine, and sulphur, and somewhat high for oleic acid, so that here the specific effects are pronounced.

The values for the spreading coefficient, represented by the difference between the adhesional work of a substance against mercury and the cohesional work against itself, are all large, so that, if what may be termed the Neumann triangle principle is applicable to spreading, all of these liquids should spread on a pure mercury surface. That they often do not spread is not surprising, since a mercury surface in ordinary air is always covered by a film of water-vapour and other vapours. This spreading coefficient increases with rise of temperature for isobutyl alcohol, secondary octyl alcohol, and benzene, but decreases for octane.

The adhesional work decreases rapidly with rise of temperature, whilst the total adhesional energy increases. The latent heat of the interface between mercury and another liquid diminishes rapidly as the temperature rises, while the latent heat of most ordinary surfaces increases with rise of temperature; the total energy of interface formation decreases, but less rapidly.

Since the halogen and sulphur atoms in organic compounds show a specifically high attraction for the mercury surface, it is to be expected that, at such an interface, the molecules should be oriented so that the halogen or sulphur atoms are turned towards the mercury. T. H. P.

781. *Effect of Adsorbed Gases on the Surface Tension of Water.* **S. S. Bhatnagar.** (J. Phys. Chem. 24. pp. 716–735, Dec., 1920.)—By means of a modified form of Ferguson's apparatus [Abs. 1244 (1913)], the surface tension of specially purified water has been measured in various gases and in a vacuum. The increase in the surface tension caused by the presence of any gas is proportional to the density of the gas excepting for carbon dioxide, the anomalous behaviour in this case being explainable by the solubility of the gas in water. T. H. P.

782. *Thermometer Screens.* **J. Aitken.** (Roy. Soc. Edinburgh, Proc. 40. Pt. 2. pp. 172–181, 1919–1920.)—Over thirty years ago the author contributed a number of papers on this subject to the Royal Society of Edinburgh. It was then shown that in sunshine the Stevenson screen always gave too high readings. The present paper presents the results of work during the latter half of 1919, in new surroundings. The actual observations published consist of daily readings, at 9.30 a.m., of thermometers exposed (1) in a Stevenson screen; (2) in a screen of the author's own design; also (3) readings of the radiation box, R.B.; and (4) readings of the black bulb *in vacuo*, B.B. The wind and general weather conditions are also noted. The R.B., described by the author in his early papers on thermometer screens, is considered to have advantages over the B.B. It is placed at the same height as the screen thermometers and its maximum and minimum thermometers record the max. radiation temperature during the day and the minimum during the night. The conclusions drawn are: (1) that the thermometer in the Stevenson screen reads always higher than that in the Aitken screen; (2) that the error of the Stevenson screen is greatest when the R.B. and B.B. readings are high and there is absence of wind; (3) that the error is small when the weather is dull and the R.B. and B.B. readings are slightly above the temperature of the air. Grouping the observations into (1) those in which the error of the Stevenson screen is 1·5 deg. F. and above; (2) those in which it lies between 1·0 and 1·5; (3) those in which it is less than 1·0, the following table is obtained:—

	Average Error in deg. F.	Average Excess R.B. over Shade Temperature.	Number of Cases.
Group (1)	2·8	47	33
Group (2)	1·1	36	7
Group (3)	0·4	22	30

The Aitken screen consists essentially of two horizontal boards with an air space between. The thermometer stem passes up through the two boards, the bulb being exposed to the air beneath the lower. An arrangement of smaller boards beneath the main ones is necessary to screen the bulb entirely from radiation. It is claimed that prolonged observations have shown that this screen, which is of simple construction, is more efficient than the Stevenson screen. In conclusion the use of the grass minimum thermometer is criticised if the readings, for different stations, are to be taken as true indications of the nocturnal radiation at those stations. The substitution of the radiation box is suggested. M. A. G.

783. *Case of the Filling up of a Depression.* **G. Guilbert.** (Comptes Rendus, 172. pp. 542–544, Feb. 28, 1921.)—On the morning of February 5, 1921, a depression approached the mouth of the English Channel from the Atlantic, became stationary, and filled up. This last phenomenon is referred to as the "compression du cyclone," and the case is cited as one which was forecasted with striking success by the author's well-known rules, the depression having been surrounded, so far as observations went, by abnormally strong convergent winds, and also having had a strong wind near the centre where a calm would be expected. M. A. G.

784. *Mirage as Observed in Egypt.* **W. H. Steavenson.** (Roy. Meteorolog. Soc., J. 47. pp. 15–19; Disc., 19–21, Jan., 1921.)—Two photographs of the phenomenon are published both showing the "reflection" of distant sand hills. The appearance presented differs in the two cases, for in the first the ridge of sand is well below the horizon, while in the second it forms the horizon and a false horizon is produced by the mirage, beneath the true one. The ridges were distant, in the one case 2¾ miles, and in the other between 5 and 10 miles, and the photographs were taken with a half-plate camera with Beck anastigmat, focus 9·5 in., at f 7·7, together with a telephoto attachment giving an equivalent focal length of 35 in. and aperture f 28. A screen and panchromatic plates are thought desirable for such work, but were not available, ordinary rapid plates being used. By suspending eight thermometers from a telegraph pole, on the shady side, at measured heights above the sand, some observations were obtained showing a very rapid lapse of temperature from the surface upwards. Six sets of observations were taken while a mirage was visible, the average values being :—

Height above sand, ft.	0·0	0·5	1·5	2·5	3·5	4·5	5·5	6·5
Temperature, °F. ..	85·5	83·0	81·1	80·4	79·9	79·7	79·6	79·6

The mirage was visible every sunny day and observations showed that it depended, as would be expected, solely on the lapse of temperature and not on the general level, having being visible at noon with a shade temperature of 49,° but absent near sunset with a shade temperature of 90° F. M. A. G.

785. *Apparent Form of the Sky-Vault.* **M. Luckiesh.** (Frank. Inst., J. 191. pp. 259–263, Feb., 1921.)—It is generally agreed that the apparent form of the sky-vault is that of a flattened dome, and various explanations, which have been advanced in the past, are reviewed. The author believes that the illusion is due to the appearance, from the earth's surface, of clouds, actually at the same level, stepping downwards *en echelon* to the horizon. The illusion is strongest on days of cumulus cloud, but may, however, be experienced on clear days, when there is a gradual change of colour from the zenith to the horizon. This conclusion is arrived at as a result of making many aeroplane ascents to a high level. Rising, in a short period, to heights of four or five miles with the illusion of a flattened dome of cloud or haze strong in the mind, it is found that on passing beyond the cloud and haze of the lower layers the sky grows darker and appears like a hemispherical dome. M. A. G.

786. *Physical Theory of the Motion of the Earth's Shadow through the Atmosphere.* **H. Dember** and **M. Uibe.** (Ann. d. Physik, 62. 6. pp. 517–530, July 16, 1920.)—This paper is a report on work carried out at Teneriffe. As the sun sinks after setting, a sharp-edged shadow, cast by the earth, rises above the opposite horizon, and is distinguishable by the naked eye until its angular elevation γ reaches about 14°. γ increases more rapidly than η, the depression of the centre of the sun below the horizon, and already exceeds 10° when η is only 4°. Previous theories, mostly purely geometrical, are incapable of explaining two facts of observation. Firstly, that the rate at which the shadow rises is subject to considerable variations from day to day. Secondly, that as the shadow rises, the absolute distance of its edge from the observer first of all increases to a maximum, corresponding approximately to $\eta = 3°$, and then decreases again as the sun sinks lower. It is shown how this absolute distance may be deduced from a value of η and the corresponding observed value of γ.

The physical theory advanced is that the outermost limit of the clear sky appears to an observer to be at a distance s proportional to the square root of the brightness of the sky, measured photometrically, in the direction concerned. This has been developed in a previous report [Abs. 1546 (1920)], in connection with the apparent form of the sky-vault. The absolute distance of the shadow edge is the value of s corresponding to a line of sight from the observer to a point just below this edge, and variations in the condition of the atmosphere then easily account for day-to-day variations in the distance of the shadow, and consequently of the rate at which it rises. Photometric observations of the brightness of the shadow furnish a test of the theory. The shadow should be brightest when most distant, *i.e.*, when η is about 3°, and this is actually observed to be the case. Similar shadow phenomena accompany sunrise. M. A. G.

787. *Spectral Polarisation of Diffuse Sunlight in the Earth's Atmosphere. II. Haidinger's "Polarisationsbüschel" in the Blue Sky.* **H. Dember and M. Uibe.** (Ann. d. Physik, 63. 6. pp. 571–580, Nov. 16, 1920.)—This is a report of work carried out at Teneriffe.

Instrumental measurements of the angular extent of Haidinger's "Polarisationbüschel" [for description of phenomenon see Pernter, "Meteorologische Optik"] have shown that the result is practically the same at all heights above the horizon, though on specially favourable days, when the phenomenon is very distinct near the zenith, the measurement there may be about 45′ greater than at 15° above the horizon. However, on clear days, shortly after sunset or before sunrise, a sensitive and practised eye may see the "Büschel" in every direction and it *appears* strikingly greater near the horizon than in the zenith. The authors have studied this subjective phenomenon experimentally by a procedure similar to that adopted by them in the case of the apparent variations in the sizes of the sun and moon at different elevations (*ibid.*, 61, p. 353, 1920), and find that the apparent size near the horizon is about twice that at the zenith. A physical explanation is sought, and it is shown that the apparent size of the "Büschel" is dictated by the apparent form of the sky-vault, which has been studied elsewhere [Abs. 1546 (1920)]. Observations are quoted in support of this theory. M. A. G.

788. *Motion of the Earth's Polar Axis; 365-Day Period due to Change of Distribution of Air Masses.* **W. Schweydar.** (Preuss. Akad. Wiss. Berlin, Ber. No. 20. pp. 357–366, 1919.)—The earth's polar motion is, as is known, composed mainly of two oscillations of the pole, with periods of 433 and 365 days respectively. The former period, which is constant and has been accurately determined by Wanach, is known as Chandler's period; it is the period of force-free nutation of the earth's axis. The interference of the two kinds of periods gives rise to the 6-year cycle. The 365-day period is variable and has hitherto not been explained satisfactorily, although Spitaler (Petermann's Mitteil. Suppl. No. 137, 1901) calculated that the average difference between the distribution of the mass of air above the earth in Jan. and July would shift the pole by 0″·1. The publication by Gorczynski of isobars for each month for the whole world, has enabled the author to make a calculation of the form of the polar path over a series of years, and it is found that the change in the distribution of the mass of air does give a curve of polar oscillation which agrees reasonably well with the observed polar motion, both as regards magnitude and direction. After 6 years the theoretical curve comes back to *near* the starting point, but without reaching it; and in the succeeding cycle (1906–11) behaves similarly, although the shape and dimensions differ from those of the preceding cycle. Owing to the non-uniformity of the data which it has been necessary to employ, the agreement could, it is felt, not be expected to be closer; and it is pointed out that for the study of polar motion it would be very helpful, if tables of the actual isobars for each month for the six years subsequent to 1900 were prepared by meteorologists. **L. H. W.**

789. *Physical Oceanography.* **A. L. Thuras.** (Washington Acad. Sci., J. 11. pp. 132–135, March 19, 1921.)—Physical oceanography is concerned with the physical properties of the sea such as temperature, density velocity, etc. The physical observations in the Atlantic indicate that a stage has been reached which calls for more thorough plans of work extending over a long period. This paper indicates that success depends on international co-operation ; the development of physical oceanographic instruments of the self-recording type, and the establishment of a permanent oceanographic laboratory. **W. A. R.**

790. *Irish Sea Tides.* **R. O. Street.** (Roy. Soc., Proc. 98. pp. 329–344, Feb. 2, 1921.)—*Laplacian Tidal Theory.*—Results connecting the tidal flow and the form of the free surface of a sea rotating with the earth, and small enough to be taken as flat, are derived from the Laplacian theory. The work is carried to a first approximation only, the motion relative to the earth being considered small in magnitude and simply harmonic with respect to time.

Application to the Irish Sea.—The results are applied numerically to the Irish Sea. It is shown that there is a steady residual drift of water northwards of such a magnitude that the sea would empty itself through the North Channel about once a year. The total mean rate of the flow of energy into the Irish Sea through the two channels is found to be about 6×10^6 ergs per sec., thus approximating to Taylor's recent result based on hydraulic flow [Abs. 311 (1920)]. This total mean rate of flow is 250 times the mean rate of dissipitation of energy, deduced from surface velocities only and assuming laminar motion throughout. Any dissipitation of relative energy must take place *in situ*, and is to be ascribed mainly to local eddying motion. **W. A. R.**

791. *Latitude Variation at U.S. Naval Observatory.* **F. B. Littell.** (Astron. J. 33. pp. 123–129, Feb. 9, 1921.)—The observations were made with the photographic zenith tube devised by F. E. Ross and used by him at Gaithersberg, Md., from June 1911 to Oct. 1914, when the instrument was removed to Washington, D.C. The present paper deals with its work there till the end of 1919. Particulars are given of the programme of groups of stars and the weighting of nightly results. Rejecting abnormal nights the probable error of a single observation is $\pm 0''\cdot086$ on the average, and the night error probably does not exceed $0''\cdot015$. The mean resulting value of the aberration constant is $20''\cdot454 \pm 0''\cdot008$. The motion of the pole is traced from these results combined with Greenwich ones, and the Kimura term evaluated for each month in 1916 and 1917.

The question of *zenithal refraction* due to a wedge of air was investigated by means of data relating to the barometric gradient, obtained from the U.S. Weather Bureau for each night of observation in 1916 and 1917, but the result proved negligible.

A concluding table gives variation of latitude for each twentieth of a year, deduced from the latitude curve. **W. W. B.**

792. *Useful Field for Small Telescopes.* **P. W. Merrill.** (Astron. Soc. Pacific, Publ. Dec. 1, 1920. Roy. Astron. Soc., Canada, J. 15.

p. 83, Feb., 1921.—Review.)—The author presses the importance of using telescopes of even as little as four inches' aperture to photograph the red end of stellar spectra, using an objective prism of 10° to 30° angle. He suggests the use of Ilford panchromatic plates sensitised by ammonia in alcohol, and provides a list of stars in which the red line of H(λ6563) shows variation, as a suitable programme. W. W. B.

793. ***Einstein Spectral Shift; New Experimental Determination.*** **J. Evershed.** (Kodaikanal Observat. Bull. No. 64. Nature, 106. p. 705, Jan. 27, 1921.—Abstract.)—In Bull. No. 39, the author's former result gave more than half Einstein's predicted shift, but St. John found a much smaller result, so the author in the spring of 1918 carried out a more extensive research, comparing the spectrum of the sun both near the centre and near each pole, with the carbon arc. The results are corrected for solar and terrestrial rotation and for the earth's radial velocity. The lines used are the strong triple C-bands from 3876·59 to 3881·78. The mean values of shift, sun *minus* arc, are in Å. units.

Centre	+ 0·0037
N. limb	+ 0·0071
S. limb	+ 0·0100

Einstein's value is + 0·082.

The late R. J. Pocock found a similar discordance between N. and S. limbs. W. W. B.

794. ***The Geodesic Precession; a Consequence of Einstein's Theory of Gravitation.*** **A. D. Fokker.** (K. Akad. Amsterdam, Proc. 23. 5. pp. 729–738, 1921.)—After a year, we must expect the earth's axis to point to a slightly different direction in the heavens, owing to the curvature of space produced by the sun's gravitation. This amounts to a small additional precession. Schouten has computed this as a problem of three-dimensional geometry [see Abs. 386 (1919)], but the author claims that the problem is one of mechanics or four-dimensional geometry, and obtains a value half as large again. In the case of the earth he obtains the value 0″·019 per annum, as a particular case of the general problem of the precession of the geodesic falling axes in the case of a planet moving in a circular orbit. W. W. B.

795. ***Personality in Estimation of Tenths.*** **S. Albrecht.** (Astron. J. 33. pp. 103–112, Dec. 11, 1920.)—Detailed investigation of "decimal equation" from data extending in some cases over 20 years respecting sixteen present and past observers at Dudley Observatory, Albany, N.Y., points to the following conclusions in regard to "decimal equation," which the author calls "personal scale."

(*a*) Different observers may differ widely.
(*b*) The same observer has a very constant scale even up to a year.
(*c*) Fatigue does not affect it, *e.g.*, five hours' continuous rapid observing shows no change.
(*d*) Some observers show no change in 10 years, others show a gradual change from year to year.

Special tests were made to determine the effect of the width of graduations and intervals. Most observers found it easier to estimate with narrow lines (about $\frac{1}{10}$ scale interval) than with wide ones. It is found that speed and accuracy are in conflict as regards the most suitable scale. A second setting rarely affects the accuracy of a determination.

The peculiarities of different observers were studied in detail. All favoured the zero graduation, and most were symmetrical about the zero and the 0·5 graduation. There is a tendency to estimate too close to the nearer graduation, which has in many cases the effect of rendering 0·5 the least likely figure. In general it takes a certain amount of practice to enable an observer to show a definite "habit," but some very satisfactory tests were made with quite inexperienced observers. The author also discusses the question of the expediency of applying a correction for "decimal equation" to individual observers' results, recommending the practice under certain conditions. W. W. B.

796. *Solar Prominences.* (Kodaikanal Observat. Bull. 63. Nature, 106. p. 610, Jan. 6, 1921.—Abstract.)—Hα spectrograms show conspicuously dark filaments, known to be due to prominences projected on the solar disc. Their azimuth is a function of latitude. Near the equator they lie along a meridan, but as the latitude increases the poleward ends swing eastwards. The mean inclination to the equator reaches 40° in latitude 30°, and at lat. 60° the filaments are parallel to the equator. If this is due to excess of easterly motion at the equator it would seem that the high-latitude filaments are older than the equatorial, but this is not confirmed by a study of the history of particular filaments. Those on the disc are flanked by a bright strip, seen best near the limb. This is said to show that the prominences rest on a bright base hotter than the ordinary chromosphere. Those seen in profile beyond the disc have their lower portion frequently obscured by a dark strip. It is suggested that the central portion of a prominence is hottest and that the lower portions of the cooler outer envelope may be dense enough to absorb light. W. W. B.

797. *Solar Variability.* **C. G. Abbot.** (Nat. Acad. Sci., Proc. 6. pp. 674–678, Nov., 1920.)—From spectro-bolometric observations it appears that the sun is a variable star with a range of $\frac{1}{25}$ magnitude in brightness with a short irregular variation of $\frac{1}{2}$ this amount in a few days. If so the light reflected from the planets should show a similar variation. The observations of Saturn and Jupiter by Guthnick and Prager by photoelectric methods afforded no confirmation of this, but the author considered their data insufficient and persuaded Guthnick to reopen the investigation. Results during the first five months of 1920 can almost all be compared with solar observations at Calama, Chili. It is doubtful whether identical dates are best, as there are two possible hypotheses in regard to solar variation. It may be simultaneous in all directions, though in view of the great and rapid changes this is physically improbable. On the other hand the known irregularity of the coronal envelope suggests that the radiation is unequal in different directions, introducing a time element between the effect of a shaft of increased intensity as it swings round in the ecliptic plane.

The great surface fluctuations of Jupiter destroy its value for the purpose. In the case of Saturn, Guthnick has allowed for most of the known causes of variation, and the author has further corrected them for phase. Omitting days unsuitable by reason of cloudy conditions at Calama or inferior seeing at Berlin, nine days of comparison remain and the tabulated results show fairly close accordance, favouring a synchronous variation of 2 % in the sun and Saturn.

High Values of Solar Radiation, 1919–20.—Five-day means from July 1, 1919, to March 25, 1920, show on the whole very high values of solar radiation, though the maximum-phase of sun-spots is well past. The mean values shown cover a range of 5 %, while those of individual days cover one of 8 %. With gradually diminishing fluctuations the radiation fell from June 1919 to October, leaped suddenly to a high mean value, maintained till December, and then leaped up again, remaining till March 1920 at a much higher value than had ever been observed before for so long a period. A very rapid fall took place towards the end of March. Since these high values belong to a cold and cloudy winter the author suggests that the direct effect of the outburst of solar activity was to produce excessive cloudiness with consequent reduction in the radiation reaching the earth's surface.

Daily values are given covering the period of the great sun-spot of March 22, with its accompanying aurora and magnetic disturbance.

W. W. B.

798. *Mars in* 1918. **G. H. Hamilton.** (Lowell Observat. Bull. No. 82. Nature, 106. p. 743, Feb. 3, 1921.—Abstract.)—Observations and drawings closely corroborate those of Lowell. Dark band round polar cap only when melting, edges indistinct when forming. The inference is that the band is not an optical effect. The author claims to have seen surface water flowing from the melting polar cap to join the Lacus Hyperboreas. He also noted seasonal development of "canals" towards equator, as described by Lowell. The "seeing" varied in patches, according to local Martian atmospheric conditions. W. W. B.

799. *Secular Perturbations of the Inclination of Planetoid Hungaria.* **G. Armellini.** (Accad. Lincei, Atti, 29. ii. pp. 388–391, Dec. 19, 1920.)—The author has taken up the investigation of the oscillation of the inclination of this minor planet, which, according to Leverrier, has the exceptionally high value of 53°. Charlier's investigation (Bull. Astronomique, p. 213, 1900) had suggested that this figure was too high and should only be 17 degrees, *i.e.*, an inclination range between 9° and 26°·6. The mere outline only is given of the author's mathematical investigation, but it is shown that the inclination only oscillates between a minimal usual angle of 19°·3 and a maximum usual angle of 22°·6. It appears, therefore, that the secular perturbations of Hungaria are, contrary to previously accepted views, only of the same order as those of the other minor planets.

L. H. W.

800. *Position in Space of Aurora Polaris.* **L. Vegard and O. Krogness.** (Geofysiske Kommission, Kristiania, No. 1. p. 172, 1920. Roy. Meteorolog. Soc., J. 47. pp. 71–72, Jan., 1921. [Review by S. Chapman].)—The observations were made in 1913–14 at the Haldde Observatory with two subsidiary stations, Gargia and Bossekop, to provide long base-lines (26 km. and 12·5 km. respectively). 260 pairs of simultaneous photographs were obtained at the ends of the longer base-line and 166 at those of the shorter one. Maximum frequency of occurrence of the lower limit of aurora appears at 100 and 106 km., though the actual range is from 85 to 140 km. The heights above the limiting base reach to some 300 km. The authors consider that the three common auroral forms (diffuse arcs, drapery-shaped arcs, and draperies) are of essentially the same physical nature and must be produced by the same kind of rays with the same penetrating power.

The direction of bands is usually along magnetic east and west, or rather makes an angle of nearly 10° with this direction. From this 10° an attempt is made to deduce negatively-charged particles as the exciting cause; and other arguments are given in support of this, so that Vegard's earlier view that the cause was α-particles is given up. Auroral rays follow very closely the lines of magnetic force. Changes of colour and distribution in reference to height are also considered. W. W. B.

801. *Two Nebulæ with Unparalleled Velocities.* **V. M. Slipher.** (Lowell Observat. Observation Circ., Jan. 17, 1921. Roy. Astron. Soc. Canada, J. 15. p. 85, Feb., 1921.)—28 hours' exposure on N.G.C. 584 gave a solar-type spectrogram showing that the nebula is receding from the sun with a velocity of 1800 km. per sec. 34 hours' exposure on N.G.C. 936 gave a solar-type spectrogram showing a velocity of recession of 1300 km. per sec. Details are given of the appearance of the nebulæ, both being classed as spiral. W. W. B.

802. *Stellar Atmospheres. Stars showing Bright Atmospheric Lines like the Sun.* **H. Deslandres** and **V. Burson.** (Comptes Rendus, 172. pp. 405–408, Feb. 21, 1921.)—Studying stellar atmospheres as distinct from the stars themselves, by a method previously explained [see Abs. 1567 (1920)], the authors have extended the list of these bright-line stars, which formerly were supposed confined to early types P, O, B, and A, and late types M, N, and R, and even in 1913 only included three K-type stars, Arcturus, Aldebaran, and σ Geminorum. They examined about 20 stars of the intermediate types, F, G, and K, and now add four K-type stars, β Ursæ Minoris, γ Draconis, α Arietis, and Pollux; and also Capella, a solar-type G star. In all eight stars the characteristic bright H_2 and K_2 chromospheric lines are more intense than in the sun, and this feature the authors do not attribute solely to temperature, but to some kind of X-ray radiation from the nucleus of the star. They consider that Capella being a spectroscopic binary, should be specially studied for variability in these chromospheric lines. W. W. B.

803. *Nebulium in Space.* **C. P. B[utler].** (Observatory, 44. pp. 55–56, Feb., 1921.)—In the hope of finding a *dark* Nb spectrum the author suggests four possible directions of research.

(1) Novæ spectra as much *before* the maximum as possible.

(2) Dark spaces in the Milky Way.

(3) "Spindle" nebulæ.

(4) Spectra of B- and A-stars, in such regions as Orion and Pleiades, in the hope that some nebulosity may lie between the observer and the stars. Suggestions are given for the method to be employed in these cases. W. W. B.

804. *Long-Period Variable W Cygni. Second Note.* **H. H. Turner** and **[Miss] M. A. Blagg.** (Roy. Astron. Soc., M.N. 81. pp. 144–150, Dec., 1920.)—In continuation of previous work [see Abs. 327 (1920)],

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the authors have considered the original observations of E. F. Sawyer, 1885–1895 in detail. Their conclusions are:

(1) Confirmation of period of 129·6 days for θ variation found from B.A.A. observations, but it is a Group II variation and not Group I.

(2) Confirmation of 243-day period for ϕ variation, Group II as before.

(3) Confirmation of sudden changes of phase in θ and ϕ, perhaps simultaneous, but in opposite directions, and the ϕ change disagrees with previous result.

(4) $2\theta - \phi$ variation doubtful.

(5) Waxing of θ variation compared with ϕ, not confirmed, but rather the reverse. W. W. B.

805. *Cepheid Variable RZ Libra.* **R. I[nnes].** (Union Observat. S. Africa, Circ. No. 51. pp. 75–76, Oct. 2, 1920.)—This variable was discovered photographically by Wood in June 1911, and again in April 1920. The author afterwards obtained 90 visual observations between May 17 and Sept. 10. It is a short-period variable with a period 1·47893 day, consisting of a flat minimum of half the period, and a rapid rise to maximum in five hours with slower decrease. The visual range is from 12·3 to 14·0 magnitude, but the photographic as estimated by Wood is from 11·0 to 15·5 magnitude.

The author points out that this is the first variable showing a period between 1 day and 1·5 days, while only three have been listed previously with periods between 1 and 2 days. W. W. B.

806. *Proper Motions of some Long-Period Variable Stars.* **A. S. Young** and **L. F. Jenkins.** (Astron. J. 33. pp. 133–135, March 9, 1921.)—Photographs of fields round faint variable stars taken with the 24-in. reflector at Yerkes between 1902 and 1908, have been compared with a duplicate series specially taken with the same instrument recently, so that the period available for proper motions varies from 9 to 15 years. The pairs of plates were measured at Mount Holyoke College, and three tables of results are given, the first considered satisfactory, the second less so, both of these being of the variable stars themselves: the third is a list of seven other stars in the fields, which show up in the stereo-comparator as having larger proper motions. W. W. B.

807. *Angular Diameter of α Orionis.* **G. E. Hale.** (Roy. Astron. Soc., M.N. 81. pp. 166–167, Jan., 1921.)—Pease and Anderson made a first approximate measure on 1920 Dec. 13, of the diameter of α Orionis with 20-ft. Michelson interferometer attached to the 100-in. Mt. Wilson reflector, at the 134-ft. Cassegrain focus, with powers ranging from 1500 to 3000. Details are given of the method adopted. The fringes are distinct even on a night of seeing 2 on a scale of 10. The preliminary result for a mean wave-length of λ5500, is angular diameter = 0″·045, yielding by means of an adopted value from three parallax determinations, a diameter of 540 million km. The angular diameter is probably correct within 10 %. Promising observations in cloudy weather were also made on α Ceti, Aldebaran and Pollux. W. W. B.

808. *Distance of Dark Nebulæ in Taurus.* **A. Pannekoek.** (K. Akad. Amsterdam, Proc. 23. 5. pp. 707–719, 1921.)—In a previous paper [see Abs. 72 (1920)] the author found evidence for absorbing matter not deep in the star clouds but much nearer us. Studying the photographs of Wolf and Barnard and the discussion of the Franklin-Adams charts by Dyson and Melotte, he obtains for the dark nebulæ in the direction of Taurus a parallax of 0″·0072 corresponding to a distance of 140 parsecs, *i.e.*, four times as far away as the Hyades, and gives their extent laterally at 70 parsecs. The oblong strongly absorbing region extends 20 by 7 parsecs, and Barnard's three small black objects have linear dimensions of 500,000, 40,000, and 30,000 astronomical units. W. W. B.

809. *Dark Nebulæ in Taurus.* **A. Pannekoek.** (K. Akad. Amsterdam, Proc. 23. 5. pp. 720–726, 1921.)—In continuation of his research [see preceding Abs.] in which only a gas-cloud was considered as the absorbing medium, the author now takes up the question from the point of view of possible solid particles which exercise a scattering influence, and also considers the dynamical consequences on the solar system of the presence of the enormous gas-cloud deduced in the previous paper, which he thinks will compel the solar system to describe an orbit about it in a period of 2 or 3 million years.

The enormous mass, however, will not be required if the gas-cloud is replaced by a dust-cloud. W. W. B.

810. *Stellar Parallaxes.* **G. van Biesbroeck and H. S. Pettit.** (Yerkes Observat. Publ. 4. Pt. 3, 4, and 5. Nature, 106. p. 674, Jan. 20, 1921.—Abstract.)—This contains photographic parallaxes of 52 stars, obtained with the great Yerkes refractor. A yellow colour-filter was used and the bright stars were reduced by about 6 mags. by a double rotating sector. The list includes some fundamental stars, and some faint stars with large proper motion. The average probable error is 0″·010. Among the results are Aldebaran 0″·047, Castor 0″·059, Procyon 0″·307, B.D + 67°·552, 0″·106; Lal 21,185, 0″·382; ζ Herculis 0″·095, Barnard's p.m. star 0″·509, Vega 0″·114. (The B.D. star has not previously been measured.) W. W. B.

811. *Emission Band at* H_β *in Nova Aquilæ III.* **W. E. Harper.** (Roy. Astron. Soc. Canada, J. 15. pp. 57–58, Feb., 1921.)—Further measures confirm the negative displacement of H_β, found previously by the author [Abs. 275 (1919)]. This agrees in sign with that found for Nova Aurigæ (1892), but not with those of Nova Persei (1901) and Nova Geminorum (1912). He discusses the results found by other observers; and gives his own figures from 20 Victoria plates and 41 taken at Ottawa, showing a displacement towards the violet of 0·77Å., in close agreement with his previous result from fewer plates. W. W. B.

812. *Catalogue of Novæ.* (Astron. Herald, Japan, Oct., 1920. Nature, 106. p. 674, Jan. 20, 1921.—Abstract.)—This catalogue starts with Tycho's nova of 1572 and includes Denning's nova of last August as No. 41. Thirty of these have appeared in the last thirty years. The list does not include the 1885 nova in the Andromeda nebula nor the other faint novæ recently found in spiral nebulæ. For each nova the R.A. and decl. for 1900 are given with date of outburst, etc., and galactic coordinates: 14 occur in the first quadrant of galactic longitude, 8 in the second, 3 in the third and 16 in the fourth; but since there are practically the same number north and south of the equator, the deficiency in the third quadrant is probably not due to its southern declination, and the suggestion is made that we are nearer the galaxy in the first and last quadrants.

W. W. B.

813. *Orbit of Spectroscopic Binary Boss 5900.* **W. E. Harper.** (Roy. Astron. Soc. Canada, J. 15. pp. 10–11, Jan., 1921.)—From seventeen observations the author finds a simple sine-curve denoting a circular orbit with period 24·65 days. The magnitude of the star is 5·72 visual, and type Ko. Mass-function 0·094. W. W. B.

814. *Secular Change in Period of δ Cephei.* **H. Ludendorff.** (Astron. Nachr. No. 5076. Nature, 106. p. 816, Feb. 17, 1921.—Abstract.)—Eddington's pulsation theory of Cepheids points to a fairly rapid secular change of period as probable, the rate of diminution in the case of δ Cephei being, according to Hertzsprung, 0·079 sec. per annum. The author, re-reducing the observations of F. M. Schwerd, between 1823 and 1826, finds them in close agreement with Hertzsprung's formula, which gives a shift of the time of maximum for 1825 amounting to − 0·0121 of a period. Schwerd's observations give − 0·0134 P ± 0·005.

He gives values computed from other series of old observations—

Goodricke, 1785 : shift − 0·036 P ± 0·005
Pigott, 1785 : shift − 0·035 P ± 0·011
Westphal, 1818 : shift − 0·010 P ± 0·008

and considers the reality of the change of period to be now beyond question. W. W. B.

815. *Calcium H and K Lines in Early Type Stars.* **R. K. Young.** (Roy. Astron. Soc. Canada, J. 14. pp. 389–408, Dec., 1920.)—The author sets out to summarise all that has been written about the "stationary" H and K lines since Hartmann's discovery in 1904, and to add to the total from unpublished data. He gives a table of 37 stars known to show peculiar Ca-lines. Two of these, 30 Ursæ Majoris and θ Virginis, are given as A type in the revised classification, and omitting these practically all are of type B2 or earlier, and if the carbon 4267 line is really a criterion between B2 and B3, several of the stars given as B3 must be B2. The inference drawn from the earliness of the type is that the Ca vapour causing the absorption is not an independent cloud, but is connected with the star. It seems safe to say that if a star is a spectroscopic binary and shows Ca-lines giving a smaller range than the other lines, it will be B3 type or earlier; and not quite so generally, if a B2 or earlier type star is a binary the Ca-lines will give a smaller range than the others. There are probably a few early stars without the Ca envelope.

The author discusses three hypotheses in regard to the Ca-cloud: (1) Hartmann's suggestion of a cloud between the observer and the star, (2) nebulosity surrounding the star but independent, and (3) Ca-cloud forming part of the star's atmosphere, but more extended than the reversing layer. The great objection to (1) is that if it is true, other classes of stars should show it. The author rejects (2) also, on the evidence of such groups as the Pleiades, and of H. H. Plaskett's pair of early type stars close together, but showing quite different Ca-lines. He therefore prefers the third hypothesis; and quotes 12 Lacertæ in support of it. In this star he found the Ca-lines giving only half the range of other lines, but differing in different years. He admits some difficulties in the application to other stars, and appeals for further observations, noting that much work required would be almost better done with a small instrument.

Notes are appended dealing with all the stars in the list. W. W. B.

816. *Changes in Period and Light-Curve of Cluster Variable S W Andromedæ.* **H. Shapley.** (Roy. Astron. Soc., M.N. 81. pp. 208–213, Jan., 1921.)—The discussion of Bailey 33 in M. 5 [see Abs. 1575 (1920)] suggests a similar explanation of anomalies in S W Andromedæ. The author analyses the Princeton observations of the variable, and tabulates the maxima observed there and elsewhere, the dates ranging from 1908 to 1919. He finds evidence of a slow change of period, and of an irregular oscillation in the time of maximum. A similar oscillation was noted in R R Lyræ. He considers that this cycle is proportional to the period and that the decrease in period discussed by Eddington and Hertzsprung may be only a phase of a cyclic phenomenon with a period of one or two centuries rather than a measurable decay of Cepheid variation. W. W. B.

817. *Distance of Galactic Star-Clouds.* **C. Easton.** (Roy. Astron. Soc., M.N. 81. pp. 215–226, Jan., 1921.)—The enormous distances, 40,000 and 60,000 parsecs, obtained by Pannekoek for the distances of two galactic clusters [see Abs. 1178 (1919)], seemed to the author very improbable, especially in some of the deductions drawn from them. He suggests three alternative hypotheses to account for the relatively large number of bright stars in the direction of a galactic cloud, and of these the only one he considers plausible demands a smaller distance for the galactic cloud. He examines five regions for which data are available, two from Greenwich catalogues and three from Groombridge's; excluding stars of large proper motion, and such others as are known to belong to the moving cluster in Perseus, paying special attention to the β Cygni region, and concludes that in that direction a not very distant, or swiftly moving, cloud of galactic stars is seen projected on another more distant galactic stratum. In general he considers that in several parts of the zone the galactic aggregations affect the density, the proper motions and spectral type of the relatively bright stars nearer to our sun. Hence if these clouds are at the enormous distances quoted, their intrinsic brilliancy must be from one to ten million times that of the sun, which he regards as an impossible assumption. W. W. B.

818. *Planetesimal Hypothesis.* **R. A. Daly.** (Sci. Monthly, May, 1920. Nature, 106. p. 642, Jan. 13, 1921.—Abstract.)—Chamberlin concluded that the earth's temperature was never very high, that its mass has slowly increased through bombardment by planetesimal dust, and that it had oceans when only one-third of its present mass. Against this the author argues that the matter composing different planets is not likely to differ much, and that the low density of the giant planets, and their surface phenomena, prove high temperatures. Thus he thinks the earth was once molten if not gaseous. Arguing also from the pitted appearance of the moon, if due to the bombardment or to volcanic action, he says the earth must show similar features if it had always been solid. Again the period of river flow calculated from the salinity of the ocean, 100,000,000 years, he considers much too small if Chamberlin is right as to the great antiquity of the oceans. W. W. B.

819. *Orbit of Spectroscopic Binary H.R.* 6169. **R. K. Young.** (Roy. Astron. Soc. Canada, J. 15. pp. 7–9, Jan., 1921.)—Binary character was announced by the author from four plates in 1919. Since then 38 more have been secured. The primary has about three times the brightness of the secondary. At times only Ca, the H series and 4481 Mg could be measured; at other times a spectrum of A0 type is shown with Fe and other metallic lines. The period assigned is 10·56 days. Mass-function 0·196.
W. W. B.

820. *Orbit of Spectroscopic Binary H.R.* 8800. **R. K. Young.** (Roy. Astron. Soc. Canada, J. 15. pp. 5–6, Jan., 1921.)—Binary character was announced by the author in 1918 from 5 plates taken with 72-in. reflector, spectrum type B3 approximately. The orbit is based on 27 plates. Period resulting from least-square solution 3·3372 days. Mass-function 0·215.
W. W. B.

821. *Probable Diameters of Stars.* **H. N. Russell.** (Astron. Soc. Pacific. Publ., Dec., 1920. Roy. Astron. Soc. Canada, J. 15. p. 83, Feb., 1921.—Abstract.)—The angular diameter of a star can be calculated if we know the visual magnitude and the surface brightness. The latter may be indirectly obtained on the hypothesis that the difference of surface brightness of two stars (when expressed in stellar magnitudes) is proportional to the difference of their colour indices. This hypothesis the author maintains with reference to the sun's surface. By several indirect methods and also by one direct method, he tries to obtain the constant giving the ratio between the variables in his hypothesis. The direct method is the case of the eclipsing variable U Cephei in which the fainter K-type component completely eclipses the brighter A-type component. If the colour-index of a K-type star is one magnitude his mean result is that the surface brightness is four times the colour index. From the colour index he computes the angular diameter, and for stars whose parallax is known this gives the linear diameter. The stars most likely to have large angular diameters will be the red stars, and he has selected as the best one to head the list, Betelgeux, the same star whose diameter Michelson recently measured in a totally different way.
W. W. B.

822. *Monoceros Stream Discovered by Axel Corlin.* **H. H. Turner.** (Roy. Astron. Soc., M.N. 81. pp. 204–208, Jan., 1921.)—The discoverer of this cluster, moving towards β Monocerotis has given places and spectroscopic parallaxes of eight "safe" stars and more than twenty others perhaps belonging to the cluster. The author draws attention to the flatness of the cluster, similar to that of the Ursa Major cluster. He also notes that the motion is nearly in the plane of the cluster. The additional stars may be divided into two groups, but their motion is not nearly in the plane of the "safe" stars. There is also some evidence of rhythmic arrangement of the stars.
W. W. B.

823. *Nova Cygni.* **P. Stroobant.** (Acad. Roy. de Belgique, Bull., Oct., 1920. Observatory, 44. p. 59, Feb., 1921.—Abstract.)—*d* Cygni used by many observers for comparison with the nova, is a variable with a range of 0·2 mag., with a period of about 26 hours. On the general question of the nature of novæ, the author favours the theory that novæ are irregular variables of peculiar physical nature, liable to sudden internal outbursts, generating large volumes of gas (H principally) which surround the object with an incandescent atmosphere, resembling the solar prominences on a large scale. W. W. B.

824. *Radiations at λλ4634–41 and λ4650 in Wolf-Rayet Stars.* **C. D. Perrine.** (Roy. Astron. Soc., M.N. 81. pp. 142-143, Dec., 1920.)—These two bands are never found in the same star [see Abs. 979 (1920)]. In addition to this 4634 and 4641 can never be seen when the bands are broad. The author suggests a possible exception in A.G.C. 23073, which appears to be on the borderland between two classes. Both 4634–41 and 4650 are shown in novæ, and the author suggests that this is due to their greater activity, while the Wolf-Rayet stars are quiescent and do not show phenomena jumbled together He suggests that these emissions are just as important as Wright's proposed 4686 as a test for classification of Wolf-Rayet stars and nebulæ. W. W. B.

825. *Emission at λλ4634 and 4641 in Wolf-Rayet Spectra.* **C. D. Perrine.** (Roy. Astron. Soc., M.N. 81. pp. 143–144, Dec., 1920.)—J. Lunt says [see Abs. 979 (1920)], that λ4641 is peculiar to novæ. Paddock, however, has found it as well as λ4634 in a Wolf-Rayet star, and Wright in several nebulæ. In this paper the author adds to this evidence. Six Wolf-Rayet stars have lines narrow enough to show both of them, and in ζ Puppis they appear double. The author does not doubt that the source of the lines is enhanced nitrogen. W. W. B.

826. *Photographic Measures of Double Stars.* **E. Hertzsprung.** (Potsdam Observat. Publ. 24. Pt. 2, 1920. Observatory, 44. pp. 56–57, Feb., 1921.—Abstract.)—Photographs were obtained with a visual telescope of 50 cm. aperture, scale 1 mm. = 16″·39, with plates of maximum sensitivity at 545 μμ, gratings being employed to equalise the magnitudes and a special filter for a similar purpose. Several other precautions are noted, and the conclusion is that for stars not too close the method is superior to eye-observation. The closest pair on the list had a separation of 1″·2, so that it is suggested that double-star observers should confine their attention to stars closer than this limit. W. W. B.

827. *Photographic Magnitudes and Effective Wave-Lengths of Nova Cygni, 1920, from Cambridge Observatory Photographs.* **W. M. Smart** and **H. E. Green.** (Roy. Astron. Soc., M.N. 81. pp. 179–181, Jan., 1921.)—Comparison stars used were γ Cygni and Boss 5026 and a diffraction grating was employed outside the objective of the Sheepshanks Coudé equatorial. The limiting dates were Aug. 26 to Oct. 2, during which period the photographic magnitude decreased from 2·53 to 7·15. The effective wave-length increased irregularly from Aug. 26, 423 μμ (F 5) to Sept. 18, 433 μμ (K), and decreased by the beginning of October to 427 μμ (G). W. W. B.

828. *Spectrum of Nova Cygni III. 1920.* **W. J. S. Lockyer** and **D. L. Edwards.** (Roy. Astron. Soc., M.N. 81. pp. 173–179, Jan., 1921.)—For previous observations with the instrument [see Abs. 405 (1921)] spectrograms were secured on 1920 Nov. 2, 5, 11, Dec. 9, and 1921 Jan. 5, the nova being about 9th magnitude throughout. Marion's "Record" plates (H and D 500) were used. The continuous spectrum seemed to have disappeared and also the absorption lines, only bright lines and bands remaining. The Balmer series of H lines, and λ4686, the λ4640 band, and Nb lines N_1N_2, λ4363 and λ4068 were strong, and other faint nebulous bands are attributed plausibly to N, which is almost certainly present in Nova Cygni. The only changes shown during the two-month period covered by the spectrograms are in the relative intensity of the lines. A plate is given showing progressive changes, and a comparison with α Cygni and N.G.C. 6210. **J. Storey** (*ibid.*, 81. p. 141, Dec., 1920.)—A reproduction is given of the spectrum obtained on Sept. 8 at the Royal Observatory, Edinburgh, with a prismatic camera of 12 in. focus, 2 in. aperture and 60° prism, both of quartz. The ultra-violet shows an intense continuous spectrum. The characteristic H bands from H_β to H_ν are well shown with a fairly faint continuous spectrum, but beyond H_η the continuous spectrum is more intense as far as λ330, beyond which again there is a temporary diminution and another brightening. W. W. B.

829. *On H-Absorption Lines in Nova Geminorum II.* **W. H. Wright.** (Roy. Astron. Soc., M.N. 81. pp. 191–200, Jan., 1921.)—In March 1912 the displacements of H-absorption lines in this nova, were discussed by Stratton [see Abs. 1057 (1920)], and his conclusion was that electric and magnetic fields do not account for the phenomenon which is certainly a Doppler-effect. A similar view was expressed by Lunt in regard to Nova Aquilæ [see Abs. 858 (1919)]. The author traverses this conclusion. His measurements of photographs taken of Nova Geminorum in March 1912 show that the dark H-lines were displaced in a manner not strictly proportional to wave-length so that the effect, though it may be a Doppler effect, is not a simple one, but must be affected by something else. He notes a peculiarity of the Balmer series of lines shown on March 30, which may suggest an explanation of this departure from the law of proportionality. Going down the series towards the red, each pair shows its more refrangible component increasing relatively to its companion. It is very weak at H_ϵ, almost equal at H_γ, and stronger at H_β. H_α is not shown, but it might be dominant there. This suggests an analogy with the solar atmosphere, different levels having different velocities. This suggestion is merely tentative, but the author cannot accept Stratton's conclusion without further evidence. **F. J. M. Stratton** (*ibid.*, 81. pp. 200–203, Jan., 1921.)—Replying to Wright, the author objects to the use of the H absorption lines as the basis of a critical argument, saying that these are parts of very complex bands, containing several bright maxima varying with the exposure, so that the data on which the argument is based are far from being homogeneous He gives figures from Allegheny and Lick plates in support of this contention, and reiterates his belief that the Doppler-effect affords the only physical interpretation yet known, though welcoming the open point of view of Wright. W. W. B.

830. *Enhanced N-Lines in Spectra of Novæ.* **W. H. Wright.** (Roy. Astron. Soc., M.N. 81. pp. 181–189, Jan., 1921.)—In consequence of Fowler's paper [Abs. 1246 (1920)] and a letter from Baxandall, on the subject of enhanced N-lines under intense electrical excitation, the author has examined spectra of novæ for these lines. He concludes that the spectrum of Nova Geminorum (II) probably showed the stronger lines of enhanced N during its nebular stage, that the "4640" stage recurred after the nebular stage was established, the best observed reversion to this type taking place six months after the beginning of the nebular period. The "4640" type was marked by the formation of broad hairy bands near λ3412, 3484, 4103, and 4640, and by the extinction of nebular bands, 3445 and 4686. The two hairy bands of greater wave-length may possibly be enhanced nitrogen. W. W. B.

831. *Enhanced N-Lines.* **A. Fowler.** (Roy. Astron. Soc., M.N. 81. pp. 189–190, Jan., 1921.)—Wright [see preceding Abs.] has called attention to the need for further laboratory observations in the ultra-violet, to support the suggested identification of two bands with enhanced N, by identifying the other two bands similarly. No N-band can at present be found near 3412; but a prominent triplet is shown near 3484. The band at 3412 does not appear to be enhanced N, O, C, Si, or S, and is still unidentified. The absence of 4379 which is frequently much fainter than 4640, does not furnish evidence against the identification of the other bands. W. W. B.

832. *Orbit of Spectroscopic Binary H.R.* 8427. **R. K. Young.** (Roy. Astron. Soc. Canada, J. 15. pp. 1–4, Jan., 1921.)—Binary character was announced by the author in 1919. Spectrum given as type A in revised Harvard photometry, and B3 in later Draper catalogue. The author thinks it is B3 or possibly B2, as the C-line 4267 is strong. 32 observations are used, a circular orbit being assumed, and the period comes out at 2·1721 days, the mass-function being 0·47. The Ca-lines do not in the case of this star agree with the component of solar motion towards the star. W. W. B.

833. *Binary* 70 *Ophiuchi.* **F. Pavel.** (Astron. Nachr. No. 5082. Nature, 106. p. 772, Feb. 10, 1921.—Abstract.)—The author finds the irregularities of the orbital motion of this star explicable on the assumption that the principal star is describing a small orbit owing to an unseen companion. He gives elements of this orbit, the period being 6·5 years, and deduces elements for the orbit of the visual pair, with a period of 87·710 years. Ratio of masses = 0·36 and combined mass of system = 1·06 times sun's mass, on the assumption that the parallax = 0″·225. W. W. B.

834. *Stellar Parallaxes.* (Allegheny Observat. Publ. 5. Nos. 4 and 5. Nature, 106. p. 674, Jan. 20, 1921.—Abstract.)—This contains parallaxes of 80 stars, many now determined for the first time. The mean probable error is 0″·008. Two only exceed 0″·1. These are P. II. 123, 0″·145 and O.A.N. 21338, 0·134. Others are, α Trianguli 0″·045, δ Cephei 0″·006, 54 Piscium 0″·096, β Andromedæ 0″·033, Furuhjelm's companion to Capella 0″·071, η Geminorum 0″·016, Lal 33439, 0″·095; P. XXIII. 218, 0″·092. The parallax of Capella is probably the same as that of its companion, as their p.m. is the same, but the companion is easier to measure. W. W. B.

835. *Astrophysical Problem of Variable Stars.* **J. G. Hagen.** (Roy. Astron. Soc., M.N. 81. pp. 226–228, Jan., 1921.)—Excluding eclipsing binaries whose variation is only apparent and not real, the rest of the variable stars may be divided into two classes, of long- and short-period, since the so-called irregular variables, such as α Orionis, may be considered as examples of exceptionally long period, while novæ and stars like U Geminorum are modifications of the δ Cephei class. Between the binary and the pulsation theories of Cepheid variation the author merely suggests that there is no known analogy of the latter, while comets supply a fairly exact analogy to the binary theory. He considers that practically all the phenomena of variation can be simply explained on the hypothesis of a larger star, with a smaller star revolving about it in an eccentric orbit, and capable when near its primary of exciting a sort of local conflagration, which will be best observed when the earth is in a particular direction with regard to the orbit. He also considers that the long-period variables only differ in phase of evolution from the short-period ones, so that he hopes the problem is after all only a single one, and the theory which is finally adopted will have to cover both classes. W. W. B.

836. *Spectroscopic Orbits and Dimensions of Three Eclipsing Variables.* **J. S. Plaskett.** (Roy. Astron. Soc. Canada, J. **14.** pp. 409–424, Dec., 1920.)—In furtherance of a programme to include spectroscopic observations of all eclipsing variables brighter than 8·0 mag. for which photometric orbits have been obtained, the present paper contains results for U Coronæ, TX Herculis, and γ Cygni, bringing the total up to twelve [see Abs. 554 (1920)]. The absolute dimensions of the whole twelve are tabulated at the end of the paper, which gives actual distance between centres of components, with radius, mass, and density of each member.

For the three stars in this paper velocity curves and relative dimensions are given. U Coronæ is of B3 type. Shapley's photometric orbit is faulty on account of some error or misprint in the epoch. This star, as well as RS Vulpeculæ supports the view that in eclipsing binaries the surface intensity is not wholly a function of temperature. TX Herculis is of type A2, and is only of 8th magnitude at maximum. Its spectroscopic phase is about an hour later than its photometric, but this may be due to a very small error in the photometric period (of about one second of time).

γ Cygni is of type B2 and the author considers Shapley's nearly circular orbit nearer the truth than Dunér's which gave a high eccentricity. The orbit now found is not considered final, as there are several difficulties in connection with it.

In reference to the complete table the author draws attention to the progression of increasing spectral type with decreasing mass, the early B stars being on the average six times more massive than the later types. W. W. B.

LIGHT.

837. *The Kingsley Kinematograph Projector.* **R. J. Trump.** (Engineering, 111. p. 208, Feb. 18, 1921.)—In the ordinary kinematograph the positive film is run through a projecting lantern which is arranged to show a picture while the film is momentarily stationary and the shutter is open. The shutter is then closed, and in the next instant the light is shut off, while the film is moved forward to bring the next picture into position. This alternation of light and darkness produces "flickering," which is not so unpleasant when the films are run at higher speeds than the rate at which the photographs were taken, but cannot be entirely suppressed in shutter cameras. In order to reduce the flicker, moreover, the speeding-up is frequently carried to such an extent that movements, walking, etc., appear ridiculously fast. The Kingsley machine works without a shutter and without any intermittently-moving parts, and can be run at any diminished or accelerated speed. The principle involved is that the film is run through continuously, and the image is kept on, the change of one picture for another being effected by a system of mirrors. These mirrors consist of a number of reflection facets mounted upon a ring, which is rotated in synchronism with the film movement. The general features of the optical system are shown diagrammatically and explained in detail. A. E. G.

838. *Analysis of the Infra-red Natural Vibrations in Doubly-Refracting Crystals.* **R. Schachenmeier.** (Zeits. f. Physik, 3. 1. pp. 26–30, 1920.)—Experimental observations of Schaefer, Schubert, and Brieger [see Abs. No. 293 (1919)] have shown that in numerous crystals the reflection-maxima occur in the short-wave infra red. In the case of sulphates, carbonates, nitrates, bromates, chlorates, iodates, and metasilicates it has been shown that the observed reflection maxima are due to the atom-groups SO_4, CO_3, NO_3, BrO_3, ClO_3, IO_3, SiO_3. In a similar manner water of crystallisation, present in the free condition, shows its own natural vibration in the infra-red reflection maxima. This latter phenomenon is considered from a mathematical standpoint. It is shown that the natural vibration of a "dipole" in a homogeneous gravitational field varies and may even become anisotropic, according to the gravitational field. In this manner it is possible to explain the optical behaviour of water of crystallisation, etc. A. B. W.

839. *Photography of Crystal Interference Figures, using Convergent Light.* **P. Sève.** (J. de Physique et le Radium, 1. pp. 161–177, Dec., 1920.)—A simple *apparatus* is described for the photography of interference fringes of crystals. Reproductions of such photographs are given in the cases of borax and cerussite. The paper contains an interesting section on sources of monochromatic light over a wide range of wave-lengths. Colour photographs have also been made, by using autochrome plates, of interference patterns produced by white light. A. B. W.

840. *Optical Properties of Crystals in the Long-Wave Infra Red.* **T. Liebisch** and **H. Rubens.** (Preuss. Akad. Wiss. Berlin, Ber. 8. pp. 211–220, 1921.)—Describes further measurements of reflecting power, transmission, etc., for the minerals wurtzite, zircon, rutile, strontianite, and cryolite. The results are given in tabular form with numerous curves. The wave-lengths used varied from $22\,\mu$ (residual rays from CaF_2) to $94\,\mu$ (residual rays from KI) in some experiments, while in others they ranged from $0\cdot5\,\mu$ to $300\,\mu$. [See Abs. 568 (1920).] A. W.

841. *Refraction in Media in Motion.* **A. Sellerio.** (N. Cimento, 20. pp. 5–18, July–Aug., 1920.)—Following up Righi's work [Abs. 1498 (1919)] based on Huyghens' principle, the author finds that the results are not varied by the semi-transparent film having a thickness or by its thickness being slightly wanting in uniformity, and he considers the general case of its being prismatic in form; but comes to a conclusion that Huyghens' principle is itself in disaccord with the reversibility of rays of light. A. D.

842. *Annealing of Glass.* **L. H. Adams** and **E. D. Williamson.** (Frank. Inst., J. 190. pp. 597–631, Nov., and pp. 835–870, Dec., 1920.)—This is a much fuller account of the work previously described [see Abs. 1587 (1920)], including an account of the manner in which temporary and permanent stresses may arise in glass. Full details are given of the measurements made on different kinds of glass and a number of equations which are convenient for calculating the stresses due to heating or cooling various shapes of glass are also included. J. W. T. W.

843. *Visibility of Thin Threads.* **W. Einthoven.** (K. Akad. Amsterdam, Proc. 23. 5. pp. 705–706, 1921.)—A discussion of the factors affecting the observation of very thin threads. Any thread which can exist can be made ultra-microscopically visible, for it is estimated that a thread of diameter equal to one-millionth of the diameter of the H molecule would be just visible. It is concluded that with commercial microscope objectives a serviceable image of a thread of $0\cdot04\,\mu$ diam. may be obtained. J. W. T. W.

844. *Possibility of Optical Images of Molecular Lattices.* **M. Wolfke.** (Phys. Zeits. 21. pp. 495–497, Sept. 15, 1920. Paper read before the Schweiz. Phys. Ges., Zurich, April, 1920.)—It is obviously impossible to obtain a direct photograph of any molecular structure, such as a crystal lattice, since, in order to show the lattice structure, the wave-lengths of the light employed must be too short for the lattice to act as a continuum, so that each molecule will give rise to a distinct diffraction image. And this primary image cannot give rise to a secondary interference image, as the lenses and mirrors will act as discontinua, making ordinary reflection or refraction impossible. But the production of such a secondary image is treated analytically in two stages, and it should be feasible to devise an optical arrangement, based upon the analytical procedure, in which an X-ray primary diffraction image should be photographed and the photographic image employed to give a secondary image with visible light. The result would not, in general, be a true image, since it would reproduce merely the intensity (amplitude) distribution, omitting the phase distribution which plays a prominent part in the formation of the secondary image. These led the author to formulate the proposition :—The diffraction image of the diffraction image of a symmetrical object having no phase-structure, illuminated by a monochromatic, parallel beam impinging perpendicularly upon it, will be a correct image of the object. This is proved analytically in the present paper, the proof being based on the author's general equations of the theory of images [Abs. 176 (1913)]. The author has confirmed this experimentally by means of a parallel beam of light from the yellow Hg-line, in the case of various types of molecular structures. To obtain a sharply defined image a strong source of light should be used, with a very small punctiform collimator aperture. The analysis shows that the magnification in diameters is in the ratio of the two wave-lengths employed. With X-rays and ordinary light, respectively, the magnification is about 10,000 diameters, and by suitably choosing the optical system this may be increased to 10^6 or 10^7 diameters. The X-rays giving the diffraction image must be reflected from one face only of a crystal. The possibility of obtaining such pictures has been suggested by E. Hupka [Abs. 1664 (1913)]. G. W. de T.

845. *Sensitiveness of Different Parts of the Retina.* **R. L. Waterfield.** (Brit. Astron. Assoc., J. Nov., 1920. Roy. Astron. Soc. Canada, J. 15. p. 84, Feb., 1921. Abstract.)—As results of experiments the author concludes that :—(1) The outer is more sensitive than the inner side of the retina for red or green light. This also holds for the average star. (2) With green light the lower part is more sensitive than the upper : with red light and with the average star the reverse holds. (3) With red light direct vision is more sensitive than averted, though with white stars averted vision gives more sensitiveness, the advantage disappearing as stars become red. (4) With red light the greatest sensitiveness is found in the upper and outer quadrants of the retina between 1° and 3° from the centre. Variable-star observers should use the averted vision method. W. W. B.

846. *Deviation through Prisms.* **H. S. Uhler.** (Optical Soc. of America, J. 5. pp. 12–13, Jan., 1921.)—Southall has recently given a trigonometrical formula for the calculation of the angle of incidence of a ray which traverses a prism in a principal section and emerges under a prescribed angle of deviation [Abs. 242 (1921)]. Some years ago Uhler gave a logarithmic solution of the same problem for the case of a ray traversing a prism obliquely [Abs. 1132 (1913)], and the present paper gives the simplified formulæ obtained when the path of the ray lies in a principal plane. A. W.

847. *Absorption and Scattering of Light.* **A. Schuster.** (Roy. Soc., Proc. 98. pp. 248–254, Dec. 3, 1920.)—A theoretical discussion of the transmission of light through a medium the molecules of which have only one free period and vibration. The mathematical treatment of the subject shows, among other things, how erroneous is the common impression that the so-called anomalous refraction is due to the absorption of light in the medium. It is, on the contrary, the perfectly normal result of the changes in refractivity introduced by the excited vibrations of the oscillators, and of the scattering of light which accompanies them. True absorption, *i.e.*, direct conversion into heat, acts in the direction of diminishing the influence of the molecular oscillations on refractivity. At present no data are available for determining the quantity on which the absorption depends. **A. W.**

848. *Tracing Rays through an Optical System; Discussion of Smith's System.* **J. P. C. Southall.** (Optical Soc. of America, J. 5. pp. 14–21, Jan., 1921.)—A discussion of T. Smith's method of tracing rays through an optical system [Abs. 1062 (1920)]. The main feature of the method lies in the fact that the formulæ used do not necessitate the evaluation of the magnitudes of many angles, sines and cosines only being needed in most cases. It is here shown how the same result can be obtained by a comparatively simple trigonometrical transformation. **A. W.**

849. *Scattering of Light by Gas Molecules; New Determination of Avogadro's Constant.* **J. Cabannes.** (Ann. de Physique, 15. pp. 5–149, Jan.–Feb., 1921.)—All the hypotheses put forward to explain the propagation of light in a transparent gas allow of the prediction that light will be scattered by the gas molecules. In the case of isotropic molecules this scattering is in accordance with the laws given by Rayleigh. The author has now calculated the intensity of the light scattered laterally by a transparent gas for the case where the anisotropic molecules have the symmetry of an ellipsoid with three unequal axes. It is shown that the observations of Abbot and Fowle on the transparency of the atmosphere lead to a value of Avogadro's constant greater than $6 \cdot 6 \times 10^{23}$, and probably very close to that number. Quantitative measurements are described of the scattering of light by the molecules of a transparent gas. For the measurement of very feeble luminosities photographic photometric methods were employed. In agreement with Strutt, the author has found that the light scattered laterally by the molecules of a gas is not, in general, completely polarised, and his results for the degree of polarisation agree with those of Strutt except in the case of argon. For this gas the author finds the polarisation of the scattered light to be complete. It is shown that the intensity of the light scattered by a transparent gas is not exactly proportional to the square of the refractivity, and that it appears to depend, like the degree of polarisation, on the symmetry of the molecules.

Avogadro's Constant.—From absolute measurements of the ratio between the luminous intensity of the light scattered by argon and the intensity of the incident beam, a new determination was made of the value of Avogadro's constant. The value thus obtained was $(6 \cdot 9 \pm 0 \cdot 25) \times 10^{23}$. This determination is based on the following hypotheses: (i) In a transparent gas the number of the scattering particles is the same as that of the molecules. (ii) Argon, whose molecules are isotropic, obeys Rayleigh's laws. [See Abs. 415 (1921).] **A. W.**

850. *Doppler-Effect at Moving Surfaces of Discontinuity.* **K. Uller.** (Zeits. f. Physik, 4. 1. pp. 109–117, 1921.)—A mathematical treatment which does not admit of brief abstract. [See Abs. 1238 (1915) and Abs. 1194 (1920).] **A. W.**

851. *Ghosts and Oculars.* **L. Bell.** (Am. Acad., Proc. 56. pp. 45–58, Feb., 1921.)—The author discusses the formation of "ghosts," varying in number from the single second-order ghost formed by a single lens to the possible 45, due to the ten reflecting surfaces of the 5-lens Beck isostigmat objective. The intensities of individual ghosts of the second order, the only ones worth considering, are 7 or 8 magnitudes fainter than the real image and can generally be thrown sufficiently out of focus to make them practically invisible. The question of eyepieces has not, the author considers, received sufficient attention, though half the light lost in a telescope is lost in the eyepiece. He illustrates fifteen different forms of ocular. Five of these are "single" lenses: the single plano-convex lens, the Coddington eyepiece, the simple achromat, the triple achromat, and the mono-centric Steinheil; the rest doublets: the Ramsden, Ramsden achromatic, Kellner, Zeiss and Steinheil, long relief ocular, ordinary Huyghenian, Airy, Mittenzwey, Tolles, and one other strongly recommended by the author, specially intended to improve the colour correction. In general for lower powers the objectives of telescopes are under-corrected, and for higher powers over-corrected. It is therefore better to have the lower-power oculars rather over-corrected and the higher ones under-corrected. The author thinks that objectives should be corrected for a rather lower power than is customary. W. W. B.

852. *Experiments on Half-tone in Relation to Photo-Lithography.* **W. J. Smith, E. L. Turner, and C. D. Hallam.** (Phot. J. 61. pp. 90–92; Disc., 92, Feb., 1921.)—In continuation of some experiments carried out in 1916, the rendering of gradations in photo-litho half-tone work has been examined. In these experiments two methods are employed, and the results which they yield lead to the neglect of certain other methods, such as removing the half-tone screen and exposing through a sheet of glass, either plain or ground, and the use of abnormally large, or fancy stops. The methods referred to are the securing of the practical closing of the high-light dot by increased screen distance, and the Sears' high-light method. The screens used for most of the work are of 65, 100, and 125 lines per inch. The results obtained show that the high-light effect can be obtained by the use of one stop. The difference between the gradation of a wet-collodion negative and a dry-plate is less marked than in the ordinary half-tone. In the direct method the greatest loss is in the lighter tones; with the Sears' method the greatest loss is in the lower tones, which are reduced to a common black. A. E. G.

853. *Action of Light on the Photographic Plate; the Schwarzschild-Effect.* **G. I. Higson.** (Phot. J. 61. pp. 35–44, Jan., 1921.)—The present paper is largely an attempt to apply the results obtained previously in the investigation of the photochemical law of the silver halide grain to the case of actual photographic plates. The following points are dealt with: (*a*) The characteristic curve, a theoretical discussion of the subject. (*b*) The shape of the characteristic curves of plates of more than one layer and of varying size of grain. (*c*) Simultaneous variation of time and intensity—the Schwarzschild-effect. Schwarzschild found that $t_1/t_2 = (I_2/I_1)^p$, where p is constant for a particular plate and varies usually from 1·1 to 1·2. It seems probable from the theory here given that the Schwarzschild-effect is only a particular case, and that the index p should vary, increasing with diminution of I; but it must not be forgotten that the variation may be to a large extent masked by the superposition of the density curves for various layers and sizes of grains. The possibility of detecting this phenomenon is under investigation. A. E. G.

854. *Action of Light on Silver Bromide.* I. **W. Ehlers and P. P. Koch.** (Zeits. f. Physik, 3. 3. pp. 169–174, 1920.)—Instead of studying the effect of light on the AgBr emulsion of the plate, the authors [see Abs. 125 (1917)] observe single grains of AgBr in a Millikan condenser, illuminated by a very steady Weule arc lamp. The salt is precipitated; the fine particles suspended in water are dried on platinum foil and introduced into the condenser, which is charged by a battery. With long exposures all the particles drifted a little in the direction of the beam when kept floating; this movement was compensated for by very slightly tilting the condenser through about 7 minutes of arc. Grains of $BaSO_4$ were kept perfectly level for 360 minutes. Grains of AgBr also kept constant or indicated a very slight increase (not decrease) in mass when in air. In nitrogen grains of $1\,\mu$ and more lost up to 10 % in mass (more with heavier grains or complexes than with small grains); in air deprived of its oxygen there was likewise a decrease in mass after 5 minutes or more. It is suggested that the loss of bromine is, in the presence of oxygen at once overcompensated by an adsorption of oxygen. In comparison experiments with dry-plates the intensity of the light had to be reduced to 1/10,000 and the exposure to 0·01 sec. to produce similar photochemical effects. An estimate of the loss of bromine is based upon these experiments. H. B.

855. *The Wedge Method of Photometry.* **G. I. Higson.** (Phot. J. 61. pp. 93–96; Disc., 96–97, Feb., 1921.)—Although as long ago as 1910 Luther pointed out that a neutral wedge may be used as a photometer, no refinements in the original procedure seem to have been devised; the method, in fact, seems to have been largely ignored, though mentioned by Renwick and described at length by Chapman Jones. A consideration of the inaccuracies inevitable with a photometer of the usual type, dependent on the light sensitivity of the eye, led the author to believe that Luther's method, which is independent of the personal factor and requires no elaborate apparatus, should be capable of development which would make it of more general use. It is merely the refinements of Luther's method that are considered in the present paper. The principle of Luther's method is as follows: The plate to be examined is exposed behind a Goldberg wedge and the resulting " wedge negative " completed. This is the normal use of the wedge as an " exposure machine." This negative is now placed behind the wedge, but at right angles to the original position, and a print is made on any suitable material through the two, when the characteristic curve of the plate appears as a clear portion on the blackened field, though the boundary is very diffuse. The wedge is thus used as a photometer and measures the densities of the negative. In the first place it is obvious that, although apparently it would be convenient to use the same wedge for both parts of the process, it is by no means necessary to do so: to secure the negative any method of exposure may be used which produces a series of parallel isopaques of a length determined by the gradation of the " photometer wedge." The particular gradation of the wedge used depends upon the particular investigations of the characteristic curve being made. It has been found in practice that it is more convenient to have one

special wedge for use as a photometer only. The reasons for this are; (1) that by employing a quarter-plate wedge with the gradation in a direction at right angles to that of the "exposure machine" wedge no difficulty occurs in "crossing," and (2) that it has been found, for the best results, that its gradation must be carefully chosen, for the characteristic curve first obtained has very diffuse edges and cannot be read with any accuracy. It has been found that by suitable means, results of the requisite sharpness can be secured by producing the characteristic curve on a suitable process plate, printing this on to hard gaslight paper and slightly reducing the resulting print. To secure a good result by this procedure a wedge increasing in density about 1·8 per in. is required. Using such a wedge a distance of 3 in. represents more than 5 on the density scale. Consequently densities up to this can be measured. A quarter-plate wedge of about this gradation and with isopaques running in the long direction is therefore invariably used as a photometer. The following points are also discussed: The wedge as an "exposure machine," the wedge as a photometer, and the neutrality of the Goldberg wedge.
A. E. G.

856. *Theory of Colorimetrics in Daylight Vision.* I and II. **E. Schrödinger.** (Ann. d. Physik, 63. 5. pp. 397–456, Nov. 3, and 63. 6. pp. 481–520, Nov. 16, 1920.)—There are three essentially mathematical papers, divided into two parts, the first two papers on lower colorimetrics or colour affinity, the third on higher colorimetrics. The main arguments were outlined in the paper dealt with in Abs. 69 and 72 (1921). Lights of equal colour (white sunlight, the white of complementary colours) are indistinguishable by the individual eye and can replace one another also in mixtures; they can be added, subtracted, and multiplied like vectors. Whether or not equal brightness can be defined in principle depends upon the possibility of integrating the Pfaff differentials of areas of equal intensity; this is dealt with in II. To connect colour equations and brightness equations by the rule that the fundamental colours must be measured in units of equal brightness (Abney) is wrong in principle. In taking measurements we can adjust for equality, inequality, greatest similarity, or greatest contrast. We proceed by similarity, *e.g.*, when we compare the same colours in two spectra of unequal intensity and in the photometry of two different hues. The author bases his deductions on line elements of the colour space, and discusses geodetics, colour blindness, the Helmholtz colour-mixing experiments, apparently contradicting the additivity principle, colour blindness, etc., on the basis of the Young-Helmholtz theory.
H. B.

857. *The Foundations of Colorimetry.* **W[ilhelm] Ostwald.** (Zeits. techn. Physik, 1. 9. pp. 173–175 and 1. 12. pp. 261–271, 1920.)—A summary of the author's views [Abs. 926 and 927 (1917)], dealing first with hueless colours (black, white, grey) and then with colours of definite hues.
H. B.

858. *Suggested Methods of Secret Signalling.* **E. Beckmann** and **P. Knipping.** (Preuss. Akad. Wiss. Berlin, Ber. 25. pp. 443–447, 1920.)—The desire for secret methods of signalling during the war has led to several suggested solutions of this problem. The first method is based on the fact that didymium glass or solutions of didymium salts show a marked narrow absorption band in the yellow near 600 $\mu\mu$. An apparatus utilising this principle is illustrated and explained. Light from a small lamp is concentrated by a condenser lens and subsequently rendered parallel by a concave lens. In the path of the rays two small screens can alternatively be inserted. One is a didymium glass plate, the other a piece of dark glass of approximately similar tint. The beam can be viewed through binoculars equipped with prisms, whereby the appearance of the dark line in the spectrum, corresponding with the insertion of the didymium glass, is recognised. An observer not equipped with such analytical apparatus would, however, see no apparent change when the screens are alternated. Two other devices, which did not evolve from the laboratory stage, are also described. In one case the spectrum of light from the lamp having been formed a fine wire is mounted so as to block a very narrow region, and the rays are then reassembled and transmitted. Under spectroscopic examination this dark line becomes evident, and can be displaced to right or left by the signaller. The change would again be inappreciable, except to observers equipped with spectroscopic apparatus. Finally a third method, based on the use of polarised light, is described. Light is transmitted through a nicol and two plates can be alternately inserted such that the light when examined through an analyser appears successively red and green. Regarded by the naked eye, without analysing apparatus, the light appears white in both cases and no change is observed. J. S. D.

859. *Talbot's Bands and the Colour Sequence in the Spectrum.* **N. K. Sethi.** (Phil. Mag. 41. pp. 211–224, Feb., 1921.)—This paper contains some observations and a theoretical discussion of the remarkable difference in the colour sequence as observed in a normal spectrum showing Talbot's bands. In the case of a spectrum showing a fairly large number of the bands these differences may be studied by placing the eye behind a very narrow slit placed in the focal plane of the telescope and moving it over the spectrum. With a spectrum showing only a small number of Talbot's bands in the whole visible region the phenomena may be easily seen without such aid. Talbot's bands may be satisfactorily observed with such small retardations by using a prism combination of small adjustable dispersion. It was found in all cases that when adjustments were properly made the colour changed from band to band in a fairly abrupt manner, remaining nearly uniform within the bright regions, but changing suddenly in passing across the minima of illumination. The spectrum with Talbot's bands is thus shown to consist, not as usual of an infinite variety of tints, but of a limited number only, depending upon the number of bands present. It is found that the condition for observing this phenomenon is not the same as that required for observing Talbot's bands at best visibility, *i.e.*, with perfectly black minima, but is slightly different, the dispersion required in the former case being about 4/5 of what is needed in the latter. If the dispersion is less than this the sequence of colour within a band is actually reversed. The colour at every point in a spectrum showing five Talbot's bands has been calculated, and the results are shown on a graph and plotted on Maxwell's colour-triangle.

New Method for Observing Talbot's Bands.—A new method for observing Talbot's bands is described, which consists, briefly, in first forming the laminar diffraction-pattern in white light and then analysing it with a spectroscope having a wide slit. This method is very convenient when Talbot's bands with small retardations have to be observed, as it is then unnecessary to restrict unduly the aperture or to use very small dispersive powers. It would be interesting to see if the phenomenon of the colour sequence in Talbot's bands could be explained on the simple theory of their formation which has been given by Schuster [Abs. 746 (1904); see also Abs. 64 (1910)]. A. W.

860. *Magneto-Optic Investigation of the Nitrogen Band* λ3883. **A. Bachem.** (Zeits. f. Physik, 3. 5. pp. 372–388, 1920. Habilitationsschrift, Bonn.)—In the investigation here described a large dispersion was used, so that a quantitative examination of the behaviour of the nitrogen band λ3883 was possible, very close doublets being ordinarily obtained. The expression ndn/H^2 given by Fortrat [Abs. 865 (1914)] for the sensitivity does not appear to be constant either for the different lines of the same series or for the same line with different field strengths. The results obtained show that the values of ndn/H^2 decrease with increasing term number and with increasing magnetic field. A new formula is given: $E = ndn/\{H^2(1 - dn/n)\}$, which for narrow as well as wide doublets, and for most of the anomalous cases which occur, gives a constant sensitivity with increasing values of the magnetic field, within the errors of observation. The formula requires infinite fields for complete purity of the components. For certain pairs of lines as well as for the triplets of the A- and B-series it was found that the sensitivity was only about one-tenth of the general value and appeared to follow no simple law. The effect of the magnetic field was found to be useful for arranging certain doubtful lines in their proper series. A. W.

861. *Ultra-red Rotation Spectra of the Halogen Hydrides.* **A. Kratzer.** (Zeits. f. Physik, 3. 5. pp. 289–307, 1920.)—Bjerrum ascribes the ultra-red band spectra to a superposition of molecular rotation upon the frequency of the oscillating nuclei. Regarding the nuclear oscillation of the molecule as harmonic, Heurlinger [Abs. 1071 (1920)] deduced frequencies in agreement with those which Bjerrum had calculated by a different method; the nuclear frequency was not constant, but shifted with m^2 (m = the rotation-quantum number) into higher frequency. The author and Eva v. Bahr, making measurements on HCl, arrived at similar results, but observed a shift into the region of lower frequency, and this was confirmed by more accurate measurements of Imes [Abs. 222 (1920)]. The author now shows theoretically that with respect to the oscillation amplitudes in question, the molecule is not to be regarded as a harmonic oscillator, but as an inharmonic oscillator. He also supports Imes as to the observation that the central line, corresponding to the nuclear oscillations, is missing in the bands. This line is, in emission, due to the quantum jump $1 \longrightarrow 0$, and in absorption to $0 \longrightarrow 1$. From the energy expression he deduces a series-formula for the ultra-red bands which agrees with the values of Imes for HF, HCl, HBr. It is suggested that Imes also observed the jump $1 \longrightarrow 2$. H. B.

862. *Natural Frequencies of Ammonium Salts in the Infra Red.* **O. Reinkober.** (Zeits. f. Physik, 3. 1. pp. 1–8, 1920.)—Experiments interrupted by the war similar to those meanwhile published by Schaefer and Schubert [Abs. 940 (1918)]. The powdered ammonium salts, chloride, bromide, iodide, fluoride, sulphate, and nitrate are compressed to discs of 37 mm., a few mm. in thickness, and their selective refraction is determined with a Fuess mirror spectrometer, with rock-salt prism, for wave-length 1 to 16·5 μ. The thickness and density (1·1 to 1·5 in case of the chloride) of the disc, depending upon the pressure applied (100 up to 3000 atmos.), made no appreciable difference in the wave-lengths (measurements within 0·01 μ). Natural vibrations are observed at 3·2, 5·8, 7 μ; the nitrate shows in addition to the nitrate frequency a faint vibration at 9·7 μ. H. B.

863. *Infra-red Frequencies of Ammonium Salts at Different Temperatures.* **O. Reinkober.** (Zeits. f. Physik, 3. 5. pp. 318–328, 1920.)—In observing the infra-red reflection spectra of ammonium salts, the author [see preceding Abs.] noticed peculiarities. The mirrors were made of powders of the salts compressed at 2000 atmos. The source of radiation (Nernst burner) was sharply defined on the mirror (I), or the radiations were distributed over the whole surface of the mirror (II); the ratio of I/II (maximum about 2) then varied with the substance and with different mirrors made of the same substance. The double band 7 μ of ammonium nitrate, *e.g.*, showed in case I a faint peak at 7·0 μ and a much more intense peak at 7·39 μ; in case II the peaks were shifted to 6·91 μ and 7·44, and the ratio of the intensities was reversed. There being temperature differences of about 40 deg. in the two cases, the author made further experiments on ammonium chloride, bromide, fluoride, using mirrors of the substances and of silver, at temperatures between − 175° and + 120°. With higher temperature the reflective power is much diminished, especially in the range of selective reflection; on the other hand, cooling brings out some otherwise very faint bands. Near 0° C. the two effects are superposed so as to produce an increase in reflective power with rising temperature, probably owing to changes in the surface layers. With falling temperature the maxima of reflection become sharper and narrower, while the wave-lengths of the natural oscillations become smaller. H. B.

864. *The so-called Cyanogen Bands.* **G. Holst** and **E. Oosterhuis.** (K. Akad. Amsterdam, Proc. 23. 5. pp. 727–728, 1921.)—Experiments are described which show that the so-called cyanogen bands are not due to nitrogen, but to one of its compounds which condenses at a much higher temperature, probably cyanogen. In some of the experiments the discharge tube was completely immersed in liquid oxygen, the spectrogram being taken through the walls of the Dewar vessel. One spectrogram thus obtained showed the bands λλ3855, 3883, and 4168 very strongly, whereas the others were absent. It is thus not impossible that the bands are due to two different carriers. [See Abs. 1171 (1920).] A. W.

865. *Effect of Concentration on the Spectra of Luminous Gases; Broadening and Enhancement of Lines.* **T. R. Merton.** (Roy. Soc., Proc. 98. pp. 255–260, Dec. 3, 1920.)—A brief discussion of the results obtained by Lecoq, Konen and Hagenbach, Saunders, King, and others, leads to the conclusion that in certain cases the three phenomena of broadening, variations in the relative intensities of the lines, and changes in wave-length, are intimately connected with the concentration of the radiating atoms in the source. A number of experiments were carried out with a view to discovering whether the phenomena of broadening and enhancement of certain lines in the case of sodium and lithium can be referred to a quasi-chemical effect as suggested by Rayleigh [Abs. 555 (1915)]. The experiments, although confirming the phenomena observed by King [Abs. 105 (1917)] for the lithium doublet at $\lambda 6708$, gave no results which would indicate any temporary associations of atoms of lithium and sodium, so further experiments were carried out with helium and hydrogen. The tubes used were of the H type, and the most interesting results were obtained with a tube filled with pure helium at a pressure greater than 50 mm. of mercury. This tube was excited by an induction coil with an adjustable spark-gap in series, and a large condenser could be put in parallel with the terminals of the induction coil. With a small spark-gap and the condenser in parallel, the lines were found to be enormously broadened, in accordance with their electric resolution; the Koch series [Abs. 1653 (1915)] was strong, and combination lines were observed at $\lambda\lambda 6635$, 4911, 5043 Å., the latter line apparently not having been observed before. These lines, which were measured approximately, were sharp on one edge and diffuse on the other, indicating the unsymmetrical nature of their electrical resolution. On admitting a small trace of hydrogen to the tube, the helium lines were broadened as before, but the lines H_α, H_β, and H_γ appeared to be perfectly sharp though faint. On further increasing the amount of hydrogen, the hydrogen lines became diffuse, and with a large quantity of hydrogen they became definitely broadened. Discussion of the results leads to the view that there is, when the amount of hydrogen is very small, a specific action of charged atoms of the same kind on one another, and that the resolution produced by a neighbouring charged atom of the same kind is vastly greater than that produced by a charged atom of another kind. These results are in agreement with those of Lockyer, but they are made in a case in which there can be little doubt as to the ultimate cause of the broadening. A. W.

866. *Effect of Asymmetry on Wave-length Determinations.* **J. W. Nicholson** and **T. R. Merton.** (Roy. Soc., Proc. 98. pp. 261–263, Dec. 3, 1920.)—An inspection of the photometric curves obtained by King and Koch [Abs. 1824 (1914)] and St. John and Babcock [Abs. 1658 (1915)] shows that the intensity distribution curves for unsymmetrical spectrum lines may be represented, without serious error, by the purely artificial device of combining two error curves. It is assumed that the intensity falls off from the maximum, on either side of the line, according to the law $I \propto e^{-kx^2}$. The asymmetry is reproduced by adopting different values of k on the two sides of the maximum. With infinite resolving power, the positions of the true and apparent maxima will be coincident; but with a finite resolving power, the energy at any point is gathered over a range prescribed, on the usual considerations of wave theory, by the diffraction pattern of the slit, and for practical purposes we may consider that the light is gathered over a range which is equal to the actual purity of the spectrum. An expression is then derived for the displacement Q, as a function of ξ (the purity of the spectrum being represented by an interval 2ξ) and i, the *index of asymmetry*. If k and k' $(k > k')$ are values of k for the two sides of the line, $i = (k/k')^{1/2}$, and the formula for the displacement is $Q = \xi(i - 1)/(i + 1)$. In most spectroscopic measurements, where the accuracy of micrometer setting far transcends the resolving power, this correction is by no means inconsiderable. Thus, on a plate on which lines separated by 0·1 Å. can just be resolved, the apparent displacement in the case of a line whose index of asymmetry is 3 is 0·05 Å., and this displacement is independent of the actual values of k and k'. Thus, though a line may be so narrow that no trace of asymmetry can be detected, it may nevertheless show a displacement which might in certain cases lead to entirely wrong conclusions. A. W.

867. *Measurements of Intensity of Spectrum Lines by Means of the Echelon.* **H. C. Burger** and **P. H. van Cittert.** (K. Akad. Amsterdam, Proc. 23. 5. pp. 790–796, 1921.)—When the intensity of the light that traverses an echelon in the direction of the optical axis is I_0, the intensity of the light leaving at an exit angle α with the axis is theoretically given by $I = I_0 \sin^2 (\pi\sigma\alpha/\lambda)/(\pi\sigma\alpha/\lambda)^2$, where λ = wavelength, and σ = width of a step. A graph of this function is given, and from this it is easy to see how the more intense of two lines may appear to be the weaker when it is in the neighbourhood of the minimum of the curve of intensity. The importance of this function when intensity determinations by the echelon are in question, is pointed out. It is possible that the different results obtained for the separations of the satellites of the green mercury line may be accounted for by an asymmetrical weakening, which is to be expected for any line within the interval $\alpha_0 = \lambda/\sigma$. Experiments were carried out on the principal line and two satellites of the green mercury line, using a photographic method for determining intensities. The results obtained show a good agreement with the theoretical intensity curve for different values of the angle α. A. W.

868. *Fluorescence of Iodine Vapours; Effect of Temperature on its Polarisation and Intensity.* **P. Pringsheim.** (Zeits. f. Physik, 4. 1. pp. 52–60, 1921.)—According to Wood [Abs. 1427 (1908) and 1075 (1914)] the fluorescent radiations of vapours are frequently polarised to a certain degree when observed in a direction at right angles to that of the exciting rays, such that the electric vector of the polarised rays is at right angles to the plane defined by the primary rays and the direction of observation. Dunoyer [Abs. 1031, and 1840 to 1842 (1912)] found a rather complex relation between the polarisation and temperature (vapours of alkali metals and of iodine). The author studies iodine vapour, excited by a Weule arc lamp, in tubes of glass (heated up to 300°) or quartz (500°) without observing any marked effect of temperature; in glass a fine whitish deposit formed above 300°, probably because the iodine then attacked the glass; the presence of bubbles in the fused quartz introduced some diffused light, but the figures also agreed on the whole with Wood's not very concordant results, and there was no marked temperature effect. Nor should any such effect be expected considering that the emission period is of the order 10^{-8} sec., whilst the rotation frequency of the iodine molecule is at least 10^{11}/sec.; any increase in the rotation frequency could not make much difference. It is necessary, however, to distinguish rotation about three axes; the rotation about the one axis would make no difference, that about the second would depolarise, that about the third would decrease the intensity; the polarisation is thus diminished but not suppressed, as the calculations of Hettner show. According to Wood the iodine fluorescence vanished at spots where the glass walls were heated by the Bunsen flame; the author does not confirm this, though quantitative photometry becomes difficult at hot spots. The diminution of the fluorescence with increasing vapour density can hardly be ascribed simply to a shortening of the mean interval between collisions. H. B.

869. *Spectral Photoelectric Sensitivity of Molybdenite as a Function of the Applied Voltage.* **W. W. Coblentz** and **H. Kahler.** (Washington Acad. Sci., J. 9. pp. 537–539, Nov. 4, 1919.)—In a previous investigation [Abs. 427 (1920)] it was observed that the spectral photoelectric sensitivity of molybdenite is confined practically within three spectral bands, the maxima of which are separated by equal intervals, when plotted in terms of frequency instead of wave-lengths. Further work, using a quartz prism giving twice the dispersion formerly obtained with a fluorite prism, appears to verify the previous results, the frequency maxima being separated by equal intervals, which decrease with temperature; the arbitrary wave-number being $n = 40$ at 25° C. and $n = 30$ at $-175°$ C.

Voltage Effect.—With some samples of molybdenite it was found that, for the visible spectrum extending to about $\lambda 6470$, the electric response is photo-positive or photo-negative, depending on the voltage applied to the terminals of the receiver. For greater wave-lengths than $\lambda 6470$ the response was photo-positive whatever the applied voltage, and the transition region, in which the action changes from positive to negative, is very narrow. Apparently two effects are concerned; the one which causes the photo-positive response acts quickly and prevails on low voltages, while the photo-negative action builds up more slowly and is predominant on high voltages. [See Abs. 1563 (1911) and 293 (1921).] A. W.

870. *Phosphorescence of Zinc Sulphide under the Action of α-rays.* **H. Herszfinkiel** and **L. Wertenstein.** (J. de Physique et le Radium, 2. pp. 31–32, Jan., 1921.)—The authors have repeated the experiments of Wood in which the duration of the scintillations produced by α-rays on zinc sulphide was measured. In the present method, however, the procedure was somewhat different. A rotating disc coated with zinc sulphide and bombarded by α-rays is examined under a microscope. As the disc turns the scintillations appear as luminous arrows, from the length of which it is a simple matter to calculate the duration, t, of a scintillation. The authors find $t = \frac{1}{9000}$ sec., which is sensibly greater than that, $t = \frac{1}{15{,}000}$ sec. obtained by Wood. Using a quartz spectrograph, the authors have also photographed the luminous spectrum emitted by the scintillations, and the phosphorescent spectrum of zinc sulphide obtained when the source of excitation was varied: light (visible to ultraviolet), kathode-rays, and canal rays. All the spectra have a common portion composed of two bands having their respective maxima in the neighbourhood of wave-lengths $0{\cdot}556\,\mu$ and $0{\cdot}486\,\mu$. In the case of the "scintillation" spectrum these bands are always followed by a kind of continuous spectrum, extending towards $0{\cdot}42\,\mu$, which is found also in the spectra excited by kathode and canal-rays but which is entirely absent under the action of luminous or ultra-violet radiations. A. B. W.

871. *Formation of X-ray Series by increasing Atomic Numbers.* **W. Kossel.** (Zeits. f. Physik, 2. 4. pp. 470–478, 1920.)—A discussion of the experimental results of Siegbahn and Stenström [Abs. 69 (1918)] and of Franck and Hertz [see Abs. 659 (1913)] on the characteristic K and L series of the elements. These observations are considered from the standpoint of the theoretical work of Bohr and Sommerfeld. A. B. W.

872. *Procedure in X-ray Spectral Analysis; X-ray Spectrometer.* **M. Siegbahn, A. E. Lindh,** and **N. Stensson.** (Zeits. f. Physik, 4. 1. pp. 61–67, 1921.)—A description is given of an X-ray spectrometer specially designed for the purposes of chemical analysis and X-ray spectral analysis. The apparatus consists of a simple combined form of X-ray tube (with hot-wire kathode), crystal support, and camera chamber. The latter can be evacuated if desired. A. B. W.

873. *Precision Measurements in the L-series of X-ray Spectra. Elements Tungsten to Copper.* **E. Hjalmar.** (Zeits. f. Physik, 3. 4. pp. 262–286, 1920.)—A detailed study of the L-series spectra of 39 elements—Copper to Tungsten. The values of all the lines observed are tabulated for each element. If details are required the original paper should be consulted. A. B. W.

874. *Absorption of Long-wave X-rays; Relation between X-rays and Light.* **Holweck.** (Comptes Rendus, 172. pp. 439–442, Feb. 21, 1921.)—The author has described in a previous paper [Abs. 663 (1921)] an experimental arrangement for the production of X-rays of long wave-length and for the measurement of their absorption in gases. Thus the variation of μ/ρ was determined as a function of λ for different gases: oxygen, $\mu/\rho = 1{\cdot}0\,\lambda^{2{\cdot}5}$; nitrogen, $\mu/\rho = 0{\cdot}8$; hydrogen, $\mu/\rho = 0{\cdot}2$; λ being expressed in 10^{-8} cm. and μ in cm.$^{-1}$, the gas being at N.T.P.

The author has recently detected a radiation for an applied p.d. of 25 volts, $\lambda_{\text{min.}}$ of continuous spectrum $= 493 \times 10^{-8}$ cm., thus definitely proving that these soft rays were not excited by parasitic ultra-violet radiations. It has been found that for a wave-length corresponding to the ionisation of hydrogen (λ about 980×10^{-8} cm., Schumann ultra-violet) a leaf of celluloid $2{\cdot}5 \times 10^{-5}$ cm. in thickness transmits 20 % of the incident radiation, whereas it transmits only 3 % of the radiation corresponding to the maximum of absorption of the soft X-rays ($\lambda = 320 \times 10^{-8}$ cm.). In such a manner it is possible, therefore, to examine the connection between X-rays and light—absorption maxima in this region having been proved to exist. A. B. W.

875. *On the X-ray Absorption Spectra of Phosphorus.* **J. Bergengren.** (Comptes Rendus, 171. pp. 624–626, Oct. 4, 1920.)—The work was carried out with a spectrometer similar to that of Siegbahn [Abs. 1397 (1919)], the rotating crystal being gypsum. Ammonium phosphate, black phosphorus of Bridgman, phosphoric acid, and red commercial phosphorus were examined. These were placed in the form of thin films on paper between slit and crystal. The wave-lengths corresponding to the limits of the bands of absorption were found to be different for the different varieties of phosphorus investigated. If $\lambda = 1{\cdot}471$ Å. for the $L\alpha$ line of tungsten, then for black phosphorus the limiting wave-length is $5{\cdot}767$ Å. and for phosphoric acid and ammonium phosphate it is

5·750 Å. Red phosphorus showed a double limit: the one component is identical with that of black phosphorus and the other, which the author attributes to yellow phosphorus, coincides approximately with that of phosphoric acid. It appears, therefore, that the chemical state of an element may have an influence on its X-ray spectrum. Allotropy undoubtedly plays an important part in the determination of the limit of the absorption band in the case of phosphorus. E. A. O.

876. *Scattering of X-rays.* **K. Herrmann.** (Phys. Zeits. 21. pp. 534–541, Oct. 15, 1920.)—A theoretical discussion not permitting of a short abstract. A. B. W.

RADIO-ACTIVITY.

877. *On the Different Modes of Radio-active Disintegration and the possibility of their Application to the Study of Nuclear Structure.* **L. Meitner.** (Zeits. f. Physik, 4. 1. pp. 146–156, 1921.)—Considerations on the possible nuclear structure of the radio-active elements, based on the work of Rutherford, Sommerfeld, Aston, and others. A short abstract is not possible; the original paper should be consulted. A. B. W.

878. *Radio-active Laws and Nuclear Structure.* **G. Kirsch.** (Phys. Zeits. 21. pp. 20–23, Jan. 1, 1921.)—Observations on the work of Rutherford, Geiger, Kossel, and others regarding the bearing of radio-active data upon the nuclear structure of atoms. A. B. W.

879. *Radio-activity and Electricity.* **F. Ehrenhaft** and **D. K. Konstantinowsky.** (Ann. d. Physik, 63. 9. pp. 773–815, Dec. 28, 1920.)—Ehrenhaft in a previous paper (*Die Naturwissenschaften*, p. 695, Aug., 1919) has described a new method of investigation of radio-active phenomena. The behaviour of a radio-active test-body of the order of magnitude 10^{-4} to 10^{-5} cm. is studied in an Ehrenhaft condenser. The proposals of the previous paper are now examined experimentally and confirmed. The paper is divided into the following sections:—

Research with radio-active test-bodies.—Scope of the investigation.—Test-bodies emitting α-particles.—T.B.'s emitting β-particles.—I. Constancy of mass of the T.B.; II. Stability of the charge on non-radio-active T.B.'s; III. Homogeneity of electric field in the condenser; IV. Constancy of mobility of T.B.'s; V. The law of resistance to motion of a T.B.; VI. Radio-active T.B.'s; Production of the T.B.; Introduction and measurement of the radio-active T.B.; Observation of the "charging-up" effect of the radio-active T.B.; Measurement of the charge-variation of the radio-active T.B.; VII. Insulation measurements of the condenser when using non-radio-active test-bodies as electrometer.—Discussion of results.

The test-bodies (T.B.'s) referred to above are small particles of mercury or selenium (approximately spherical and of diameter 10^{-4} to 10^{-5} cm.). These particles were examined in the "Ehrenhaft condenser" (1) in their non-radio-active state and (2) after coating with active material (from RaEm or polonium).

The paper concludes with a detailed description of the experimental apparatus. A. B. W.

880. *β-ray Emission from Thin Films of Elements Exposed to X-rays.* **L. Simons.** (Phil. Mag. 41. pp. 120–140, Jan., 1921.)—The general conclusions of the author are summarised as follows :—(1) It is improbable that the max. speed of ejection of electrons from different substances under the influence of X-rays of definite wave-length is exactly constant independently of the nature of the substances, and dependent only on the frequency of the incident X-rays. The present experiments have shown that throughout the whole range of motion, the distribution of electrons depends fundamentally upon the substance from which they are emitted, but the difference, if any, in the max. velocities is too small to be demonstrated by this method. (2) The experimental results point to the conclusion that there may be speeds of emission of electrons from an atom (S) when X-rays of frequency ν fall upon it given by either $\frac{1}{2}mv^2 = h\nu - {}_S(h\nu_K + h\nu_L + h\nu_M + \ldots)$, each successive speed being given by the removal of a term from the bracket, commencing with the term, or $\frac{1}{2}mv^2 + h\nu - {}_S(h\nu)_{K \text{ or } L \text{ or } M}$; the expression in brackets representing the potential energy of the electron from whichever atomic ring it was ejected, ν_K, ν_L, etc., being the K, L, etc., frequencies of the X-ray spectral lines of the parent atom (S). The experimental data agree rather better with the latter expression. (3) There is a type of electronic emission fundamentally associated with each type of X-ray emission. Assuming that it is not a necessary condition that each of the radiating atoms of one substance should be emitting all possible types of spectral lines, from those of highest energy downwards, then the energy of electronic emission of any one of these atoms is complementary to that of its wave-emission ; in other words, the "K" electron is the slowest on emergence, the concomitant "L" electron faster, and so on. A. B. W.

881. *Branching-Ratio of the Actinium Series from the Ur-Ra Series.* **A. Smekal.** (Phys. Zeits. 22. pp. 48–51, Jan. 15, 1921.)—The author explains the observed branching-ratio of the Ac-series from the Ur-series, by assuming the emission of an X_3-particle in the disintegration of UrII—the observed ratio being 3·4 %, whilst the calculated ratio on the above assumption is 3 to 4·2 %. Similarly, in the case of radio-actinium a quantitative explanation is received by assuming emission of X_3-particles. A. B. W.

882. *Isotopy of Radium and Polonium.* **A. Muszkat** and **H. Herszfinkiel.** (J. de Physique et le Radium, 2. pp. 15–18, Jan., 1921.)—Reference is made to the work of Beer and Fajans, and of Fleck, on the isotopy of RaA and polonium. The results obtained by Fleck whilst not denying the existence of the isotopy of these radio-active bodies, are insufficient from a quantitative point of view. The question is now re-examined, and the authors find undoubted evidence of isotopy of RaA and Po, by electrochemical treatment and by volatilisation.
A. B. W.

883. *Results of Recent Measurements of the Radio-active Springs in Brambach.* **P. Ludewig.** (Phys. Zeits. 22. pp. 121–123, Feb. 15, 1921.)—An examination of the radio-active content of Brambacher spring water, showing the variation of emanation-content at different times of the year. A. B. W.

HEAT.

884. *Specific Heat of Water between 5° and 50°.* **W. Jaeger** and **H. v. Steinwehr.** (Ann. d. Physik, 64. 9. pp. 305–366, Feb. 24, 1921. From the Physikal.-Techn. Reichsanstalt.)—Describes, with full details of the apparatus used and of the method of experiment, a new determination in absolute units of the specific heat of water. The formula expressing the results is $A_t = 4\cdot2047_7 - 0\cdot001768t + 0\cdot00002644_7t^2$. This gives as the value at 15° C. $4\cdot184_2$. There is a minimum at 33·5°. This value is based on the value of 1·0183 volts at 20° C, for the e.m.f. of the Weston cell and for the normal temperature scale. J. W. T. W.

885. *Heating of Wires by Electric Current in Rarefied Gases.* **H. Busch.** (Ann. d. Physik, 64. 5. pp. 401–450, March 10, 1921. Habilitationschrift, Göttingen.)—The dependence on temperature of the heat emission from thin wires in hydrogen was investigated experimentally for different pressures. The results showed the existence of two separate temperature regions, within which the dependence of the heat emission on temperature followed different laws. The division between the two regions is shown in the curves by a decided kink. With the aid of the temperature functions thus obtained the current–potential curves of resistance wires were constructed, and it was then found that for resistances having a high positive temperature coefficient backward-turning (re-entrant) characteristics were obtained, a certain portion of the characteristic showing that the current decreased with increase of the applied potential. Consideration of the stability of the effects in question showed that for a wire with a backward-turning characteristic the condition of uniform temperature distribution is unstable, and it was shown that such a wire divides itself into two sharply defined parts at different temperatures, and therefore a current–potential curve must be given showing practically constant current over a wide potential range. The theory was established by further research on iron and nickel wires, and this work cleared up some difficulties as regards hysteresis effects. A. W.

886. *Phenomena of Ignition of Gaseous Mixtures by Induction-Coil Sparks.* **J. D. Morgan** and **R. V. Wheeler.** (Chem. Soc., J., Trans. 119. pp. 239–251, March, 1921.)—The capacity and inductive components of sparks produced by induction coils are discussed. It is shown that the spark consists of a bright line, followed by a striated luminous band. The former is the capacity component and the latter the inductive component. Using explosive mixtures of methane and air, experiments were carried out with sparks in which the inductive component was varied and also the thermal content of the spark. Within limits, the energy required to explode a given mixture is constant, provided the electrical characteristics of the sparks are unaltered. Ignition is effected by the capacity component, but when this is inadequate in itself the combination of the two components will sometimes cause ignition. Under these conditions the supplementary action of the inductive component is capricious. With the methane and air mixtures used, it was found that the igniting current (in the primary of the induction coil) decreased rapidly at first as the spark-gap was increased, but there was a certain width of gap for which the current was a minimum. The value of the minimum gap varied with the percentage composition of the mixture. N. W. M.

887. *Heat Distribution on a Radiating Plane.* **K. Aichi.** (Phys. Math. Soc. Japan, Proc. 3. pp. 12–19, Feb., 1921.)—An application of Green's function to the problem dealt with in previous papers [see Abs. 732 and 404 (1920)]. J. W. T. W.

888. *Critical Temperature of Mercury.* **G. Meyer.** (Phys. Zeits. 22. pp. 76–78, Feb. 1, 1921.)—From Hagemann's results for the surface tension of mercury between 20° and 367° the molecular surface energy is calculated for 20-deg. intervals up to 360°. From the temperature variation of the molecular surface energy it is concluded that at 340° mercury consists of molecules whose molecular weight is 200, while at lower temperatures a partial association into double molecules takes place. The results then show that $\alpha(yM/\rho)^{2/3} = C - 2\cdot121t$, where α is the surface tension, y the association factor, C a constant 3125, and t the Centigrade temperature. From this the critical temperature is calculated to be 1474°, which is in approximate agreement with the results of Königsberger and of Miss Bender. A. W.

889. *Inversion Curve of the Joule-Thomson Effect in Gases.* **M. Jakob.** (Phys. Zeits. 22. pp. 65–69, Feb. 1, 1921. From the Physikal.-Techn. Reichsanstalt.)—For every gas a pressure p can be found corresponding to each value of T, such that the differential Joule-Thomson effect is zero, *i.e.*, that $(\partial v/\partial T)_p = v/T$. The author compares the data obtained on different gases, namely, ethylether, CO_2, ethylene, O, air, N, and H, and finds the mean curve with which the inversion curves of all these gases are in approximate coincidence. This curve is expressed by the relation $p = 899\cdot7 - 1\cdot167T - 1102 \times 10^4/T^2$. J. W. T. W.

890. *The Quadrupole Moments of the Oxygen and Nitrogen Molecules.* **W. H. Keesom.** (K. Akad. Amsterdam, Proc. 23. 6. pp. 939–942, 1921.)—It has been established [see Abs. 215 (1916)] that as far as the term with the second virial coefficient, the equation of state of hydrogen can be accounted for in the temperature interval between + 100° and − 100° C., by assuming the molecules to act on each other as electric quadrupoles with constant quadrupole moment. For this the repulsions which predominate at small distances had to be replaced by the forces that would act when the molecules collided as solid spheres of definite radius. At the same time the quadrupole moment of the hydrogen molecules was determined. This proved a configuration of the two nuclei and the two electrons constituting a hydrogen molecule to be very well possible in such a way that it has the demanded quadrupole moment. By these considerations it was evident that the molecular attractions can be explained for homopolar molecules too, by the electric forces exerted by the nuclei and the electrons constituting the molecules. A comparison of the quadrupole moment demanded by the equation of state with that of the Bohr-Debye model for the hydrogen moment was not made then because of the difficulties, especially with respect to magnetic properties. Meanwhile Burgers has calculated the quadrupole moment of the hydrogen molecule according to Bohr-Debye, and found a remarkable agreement with the value derived from the second virial coefficient. The objections, however, against the model render important the calculation of the quadrupole moment from the equation of state. In consequence the author now calculates the quadrupole moments for oxygen and nitrogen by this means. A table of results is given. The magnetic attraction between the paramagnetic oxygen molecules is found on calculation to be of inappreciable influence on the result. All the calculations are based on the supposition that the molecules collide as solid spheres of constant diameter. H. H. Ho.

891. *On the Equation of State for Arbitrary Temperatures and Volumes.* II. **J. J. van Laar.** (K. Akad. Amsterdam, Proc. 23. 6. pp. 887–906, 1921.)—Owing to the interval of two years which has elapsed since the appearance of Part I [see Abs. 646 (1920)], the author deems it necessary to explain some of the difficulties which have in the meantime appeared, namely: in the transition of some linear quantities into the corresponding spacial ones; the calculation of the time-average u_1^2 at high and low temperatures; the nature and mode of action of the assumed forces between the molecules, etc. The paper is mathematical throughout. H. H. Ho.

892. *Remarks on the Nernst Hypothesis.* **G. Bruhat.** (J. de Physique et le Radium, 2. pp. 1–14, Jan., 1921.)—While the measurements of specific heats appear sensibly to confirm the first part of the Nernst hypothesis—namely: that the entropy of a liquid or solid tends towards a finite value as the temperature approaches absolute zero [see Abs. 1702A (1911)], no experimental data exist for a similar confirmation of the second part of the hypothesis, viz., the equality of these values for different modifications. It is certain that the entropy variations which accompany changes of state or chemical reactions between condensed bodies, are appreciably less at absolute zero than at ordinary temperatures, but nothing exists to prove that they may vanish. The measurements of specific heat or, actually, the differences of specific heats at low temperatures, are not sufficiently exact to afford this proof. Vapour-pressure measurements, as also those of dissociation coefficients, are of like uncertainty, with the difficulty added of assuming the vapour to behave as a perfect gas. The only conclusion which may be adopted is that the Nernst hypothesis is not in contradiction with experience. From the standpoint of exact thermodynamics, the Nernst hypothesis hardly seems capable of interesting applications, *e.g.*, the complete conditions of equilibrium could only be calculated very approximately from the thermal data. The mathematical formulæ usually given for the representation of the Nernst hypothesis appear equally difficult to justify. They consist in expressing differences of energy between two condensed modifications in the form: $U = U_0 + \beta T^2 + \gamma T^3 \ldots$ When actual reactions are studied within the usual temperature limits, the development in series should be made from one of the points in the region investigated and the energy is then represented by: $U = U_\theta + \alpha(T - \theta) \ldots = U_1 + \alpha T \ldots$; the author has shown that the first two terms suffice for the case of the fusion of ice, while for the transformations of phos-

phorus even the second is negligible. Nothing, however, proves that this development may be valid as far as absolute zero, and such may not be the case. The differential dU/dT is a difference of specific heats at constant volumes, and according to the above expression, the specific-heat equation may be written: $c = aT + bT^2 \ldots$. Now in Einstein's theory, c is an exponential function of $1/T$, which may not be expanded in series starting from $T = 0$; in Debye's theory the first term in the expansion involves T^3. From the experimental standpoint, therefore, it appears convenient to replace a part of the specific-heat curve by its asymptote or by its tangent of inflection, but there seems no need to replace it by a straight line or a parabola with a vertical axis passing through the origin.
H. H. Ho.

893. *The Molecular Heat of Hydrogen.* **F. H. MacDougall.** (Am. Chem. Soc., J. 43. pp. 23–28, Jan., 1921.)—On the general basis of the quantum theory, and making use of the Bohr model of the hydrogen molecule, Krüger has attempted [see Abs. 14 (1917)] to calculate that part of the specific heat of hydrogen which is due to the energy of rotation. The molecular heat of hydrogen at constant volume has been determined by Eucken from 36° to 273° abs. If from his values 2·98 be subtracted, then the observed values of C_{pr} are obtained. These are much higher than the values calculated by Krüger, even when the contribution to the molecular heat due to the vibration of the nuclei with reference to each other is taken into account. It is the author's view that the cause of the disagreement between Krüger's theory and the results of experiment is due to his assuming that the motion of rotation (or of precessional vibration) corresponds to but two degrees of freedom. Accordingly the author investigates the effect of assuming three degrees of freedom for the rotational energy. At high temperatures the atomic vibrations must be taken into account, although no appreciable effect on the molecular heat is found until about 1000° abs. The author, though aware of the many objections that have been raised to Bohr's model of the hydrogen molecule, opines that the actual hydrogen molecule may have gyroscopic properties similar to those assumed in this paper. The assumption of three degrees of freedom of rotation, implies that the angular velocity of rotation of the hydrogen molecule about the axis joining the two nuclei is not an absolute constant, but can be changed by collisions or otherwise. In applying the theory of quanta, the characteristic frequency is supposed to be given by the frequency of the precessional vibration. The molecular heat of hydrogen is found to be capable of calculation for temperatures ranging from the very lowest up to 2600° abs. The view that diatomic molecules have three degrees of freedom as regards rotation, is strengthened by a consideration of the molecular heat at constant volume of chlorine. Reduced to the ideal state, Nernst gives 5·85 for the value of C_v for chlorine at 0° C., and this high value can only be accounted for by assuming three degrees of freedom for the rotational energy. The author deems it impossible for the vibrational energy of the atoms with reference to each other to be sufficiently great at 0° C. to allow of the chlorine molecule having but two degrees of freedom of rotation.
H. H. Ho.

894. ***A Mechanical Model for the Representation of Changes of State and Entropy in Gases.*** **R. v. Dallwitz-Wegner.** (Phys. Zeits. 22.

pp. 103–109, Feb. 15, 1921.)—The model now described, represents by the suitable movement of masses not only gaseous changes of state and the mechanical gas laws, but also affords a mechanical interpretation of the idea of entropy. By it the gaseous laws are shown to remain valid when the molecules no longer possess translatory motion, but only execute rotations about force-centres. Similarity is shown between this model and the procedure in Bohr's atomic model. The author opines that the model may be serviceable for the development of a kinetic theory for liquids and solids, since at low temperatures the components of gases should execute rotatory movements about force-centres. The paper is mathematical throughout and illustrated by two diagrams. The model may be obtained from A. Pfeiffer, of Wetzlar. H. H. Ho.

895. *Determination of Quanta-conditions by Means of Adiabatic Invariants.* **G. Krutkow.** (K. Akad. Amsterdam, Proc. 23. 6. pp. 826–837, 1921.)—In a series of papers Ehrenfest has shown that only such functions of the general coordinates of a mechanical system may be quanticised as are adiabatic invariants [see Abs. 403 (1917)]. These functions can always be found [see Abs. 1224 (1919)]. Moreover, theory may answer the question as to the number of essential adiabatic invariants, which in accordance with the quanta-hypothesis have to assume discontinuous values. If the assumption be made that the density of probability of the motion of the system, when not adiabatically acted upon, does not depend explicitly on the time, and if then by means of some hypothesis or some theorem which is derived from the properties of the system, the time-mean of a phase-function be replaced by a numerical mean, it follows immediately that the number of essential invariants is equal to the number of determining quantities of the system which is left after the numerical mean has been determined. By the determination of the adiabatic invariants, and the separation of the essential ones, the uncertainty as to the choice of the forms of motion which are admissible on the quanta-hypothesis, becomes materially lessened. It must not be expected that the adiabatic invariants found are necessarily those which have to be quanticised: any arbitrary function of those quantities is again an adiabatic invariant and has thus equal claims to be selected. However, this liberty of choice can be somewhat restricted; there is a further condition—for the quanta functions which may be given a simple statistical interpretation and which is fulfilled wherever the theory of quanta has been applied with success. It was introduced by Planck as a fundamental theorem for a complete determination of the quantities which have to be quanticised. A new proof is now given by establishing a connection between the adiabatic invariants and the phase-space. This connection, which arises in a natural way with a concept derived from statistical mechanics, strengthens the bond between it and the theory of quanta. In view of this most important connection the author opines that the only justification of the expression "action-quantum" is the fact that it recalls to mind the dimensions of the phase extension. Another important concept is Planck's coherence of degrees of freedom; its meaning is shown very clearly by a juxtaposition of the properties of a conditionally periodic system and a Boltzmann ergode. This coherence of degrees of freedom must be very clearly distinguished from what is called "degeneration." For instance, from the author's standpoint an ergodic system is to the highest degree coherent, but could in no case be called degenerated. For a degenerated system the number of essential adiabatic invariants is greater than that of the degrees of freedom; for a coherent system it is smaller. The question arises, Must the supernumerary adiabatic invariants of a degenerated system be quanticised, or, as suspected by Schwarzschild, is the number of quanta-conditions smaller for such a system for the normal case without degeneration? For the solution of these questions the three steps which have been taken, namely; (1) establishment of the adiabatic invariants; (2) selection of the essential ones; (3) normalisation of the latter, are insufficient. To get nearer the solution the quanta-functions must, in the author's opinion, have a meaning which is independent of the system of coordinates. This, he thinks, may be postulated, *i.e.*, if the quanta-laws are really physical laws they must necessarily satisfy this condition. The question arises of how to formulate this new invariance of the quanta-functions. The author does not discuss this in general, but remarks that a reversion may be made from the canonical equations, which are so convenient in the theory of quanta, to the equations on Cartesian coordinates. Here the invariance in question means invariance with respect to the groups of rotations and translations; vector-analysis thus provides the means of testing hypothetical quanta-quantities for the new postulate. In special cases the quanta-quantities may be separated without ambiguity, *e.g.*, in the mechanical systems considered by Planck. In some cases, however, an ambiguity remains, which is eliminated as follows: By putting all but one of the quanta-quantities equal to zero, a singular motion must be obtained. In this manner a connection is made between the above methods and Planck's theory on the physical structure of the phase-space, Planck's singular motions forming the last step in the series. Sections of the paper consider: (1) the fundamental equation; (2) when H contains a variable parameter; (3) phase-space and adiabatic invariants; (4) the coherence of degrees of freedom; (5) degeneration. The author is fully conscious of the fact that by the above considerations the difficulties which still beset the theory of quanta are in no way removed, but only shifted. He thinks that even the possibility of such displacement deserves attention, and that in special cases the general theory tentatively sketched out here may be found useful.

H. H. Ho.

SOUND.

896. *Period of Vibrations of Fundamental of Thin Rod, in the form of a Truncated Wedge, for Rotations about its Base.* **L. M. Swain.** (Phil. Mag. 41. pp. 259–266, Feb., 1921.)—This paper contains an attempt to apply Rayleigh's method for the calculation (Theory of Sound, i. §§ 88–89) and to find the accuracy likely. It is found that a possible error of about 6 % will result. E. H. B.

897. *Logarithmic and Graphic Exhibition of Musical Intervals.* **J. Würschmidt.** (Zeits. f. Physik, 3. 2. pp. 89–97, 1920.)—Uses the logarithmic method of representing the intervals and scales: Pythagorean, just intonation, and equal temperament. This is done in diagrams and tables, in which latter there are 30,103 steps (or 100,000 times log 2) to the octave. **A. Schmidt** (*ibid.*, 3. 4. pp. 250–254, 1920) and **J. Wallot** (*ibid.*, 4. 1. pp. 157–160, 1921).—Remarks on the above. E. H. B.

898. *Speed of Longitudinal Waves in Gelatine.* **P. Herbolsheimer.** (Zeits. f. Physik, 3. 3. pp. 182–195, 1920. Extract of Dissertation, Erlangen.)—An experimental investigation conducted by an optical method, mean results from 136,400 to 162,600 cm. per sec. being determined. E. H. B.

899. *Perception of Sound Direction.* **E. M. v. Hornbostel** and **M. Wertheimer.** (Preuss. Akad. Wiss. Berlin, Ber. 20. pp. 388–396, 1920.)—A general discussion of the subject and the various views that have been held respecting it. E. H. B.

900. *Perception of Shortest Tones of Under-Water Transmitter.* **E. Lübcke.** (Zeits. techn. Physik, 2. 2. pp. 52–53, 1921.)—With a frequency of 1000 per sec. whether in air or in water and with a large transmitter or a small one, a sound lasting nine or ten periods (say, one-hundredth of a second) is necessary for the production of a good tone impression. E. H. B.

901. *Electrical Apparatus for Submarine Acoustics.* **F. Aigner.** (Elektrot. u. Maschinenbau, 38. pp. 487–488, Oct. 10, 1920. Paper read before the Elektrot. Verein.)—An account of a semi-popular paper read before this society. E. H. B.

902. *Development, Action, and Results of Electromagnetic Under-Water Sound Transmitters on the Telephone Principle.* **A. du Bois-Reymond, W. Hahnemann,** and **H. Hecht.** (Zeits. techn. Physik, 2. 1. pp. 1–8, and 2. 2. pp. 33–40, 1921.)—Describes an apparatus which is contained in a water-tight chamber whose base is the vibrating membrane and to which (inside the chamber) is fixed an arrangement carrying pole-pieces and a coil to take an alternating current and so produce vibrations in an electromagnet mounted in the membrane. By reaction vibrations are thus produced in the membrane itself. E. H. B.

903. *Electromagnetic Transmitter.* **H. Lichte.** (Zeits. techn. Physik, 2. 1. pp. 12–17, 1921.)—A box contains an electromagnet whose armature is a stud on the middle of the membrane forming the top of the box. Thus alternating currents give the desired vibrations. E. H. B.

904. *Musical Scale based on Interval CG as Centre of System.* **J. Goold.** (Roy. Soc. Edinburgh, Proc. 40. Pt. 2. pp. 161–171, 1919–1920.)—Calls special attention to the symmetry which results if the *interval* CG instead of the *note* C is taken as the centre of the system. The chromatic scale of C is then exhibited as follows:—

A	E	B	F♯
F	C	G	D
D♭	A♭	E♭	B♭

in which we ascend by fifths in reading along the lines, but descend by major thirds in passing down the columns. The ratios of these intervals are shown as derived from the harmonic series of D♭. Many other curious properties and relations are referred to and an extended scale is given on the plan of the above diagram. E. H. B.

905. *Siren Harmonics and a Pure-Tone Siren.* **E. A. Milne** and **R. H. Fowler.** (Roy. Soc., Proc. 98. pp. 414–427, March 3, 1921.)—Deals theoretically and experimentally with these siren problems. When the holes are round overtones are present, but a form of hole is discovered by calculation for which it is expected the tone should be pure. It is found, however, when experimentally realised, to have four faint overtones, but is much better than the Seebeck siren. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

906. *On the Behaviour of Molecules towards Free Slowly-moving Electrons.* **H. F. Mayer.** (Ann. d. Physik, 64. 5. pp. 451–480, March 10, 1921. Dissertation, Heidelberg.)—Investigations of the passage of electrons through matter are of fundamental importance in regard to our knowledge of the constitution of matter, since all modern theories of atomic structure consider atoms as composed of a variety of combinations of positive and negative charges. The author develops a theory of absorption of slowly-moving electrons by matter and verifies his deductions by a series of experiments on the absorption of slowly-moving kathode rays in argon. A. B. W.

907. *Existence of Sub-electrons; Theory of Probable Cause.* **E. Regener.** (Preuss. Akad. Wiss. Berlin, Ber. 32. pp. 632–641, 1920.)—Millikan and others have obtained a well-defined elementary electric quantum, while Ehrenhaft and his students have obtained various values much below Millikan's result [see Abs. 970 (1918)]. The present paper discusses the probable cause of these discrepancies, and shows it is possibly due to the effect of a layer of condensed gas, which would have a marked effect on the very small particles used by Ehrenhaft in his experiments. Research is in progress to test the correctness of the theory here advanced. A. W.

908. *Possible Magnetic Polarity of Free Electrons; Estimate of Field Strength at the Electron.* **A. H. Compton.** (Phil. Mag. 41. pp. 279–281, Feb., 1921.)—Recent unpublished work of Shimizu and C. T. R. Wilson has shown that the paths of β- and secondary-rays, excited by X-rays in air, usually terminate in converging helices. Thus out of 66 tracks examined 52 are of distinctly helical form, 12 are uncertain, and only 2 or 3 tracks show no general curvature of this type. The axes of the different helices have a random orientation. The author makes certain very interesting deductions from these observations. Though the spiral form of the paths would suggest a motion of the particles in a magnetic field, the chance orientation of the axes of the different helices shows that these axes are not determined by any external magnetic field, but are rather characteristic of the individual β-rays. More specifically, the axis of the helix must be parallel with some polarity of the β-particle that is relatively permanent in direction. Furthermore, if the magnetic field does not decrease whilst the velocity of the β-ray diminishes, the tracks of the particles will be *converging* helices such as appear on the photographs.

The author explains these observations and deductions by supposing that the β-particle acts as a magnetic doublet as well as an electric charge, and is therefore capable of producing the requisite magnetic field in a medium susceptible to magnetisation. It is estimated, on these assumptions, that the *intensity of the magnetic field induced* at the electron should be *of the order of* 3000 *gauss.* This is approximately the field which would be required to produce the observed curvature.

Various interesting possible applications of the theory, should it prove correct, are proposed in conclusion. **A. B. W.**

909. *Electrostatic Induction in an Infinite Metallic Sheet.* **E[leonora] Freda.** (N. Cimento, 20. pp. 47–50, July–Aug., 1920.)—A mathematical revision of some of the formulæ in an earlier paper [Abs. 120 (1921)]. **A. D.**

910. *Stability of Electromagnetic Matter.* **M. v. Laue.** (Phys. Zeits. 22. pp. 46–48, Jan. 15, 1921.)—The demonstration of W. Schottky's conditions for the stability of electromagnetic matter [see Abs. 693 (1921)] rests upon the two general and established propositions that:—(1) In a self-contained, steady system at rest relatively to a reference frame K the volume integral vanishes for the time average value of every component of the tensor p of the absolute strains; (2) the sum $\Sigma[3, 1]p_{ii}$ of the Maxwell strain tensor is equal to the energy density; in other words, $\Sigma[4, 1]T_{ii} = 0$, where T stands for an electromagnetic world-tensor. (2) is applied only to the energy of interaction of the charged particles, in which case it is easily seen to be valid. Schottky's equation (1), which defines L, the internal kinetic energy, is equivalent to writing $p_{ik} = g_i q_k$, giving to the impulse density g the Newtonian value μq, where μ is the mass density, and q is velocity, when he obtains $\Sigma p_i = \mu q^2$. The omission of relativistic corrections means neglecting the effect of electronic motions within the atom, and this is not always insensible. A more serious question is as to the effect of omitting t_{ik} from the exact equation $p_{ik} = t_{ik} + g_i q_k$, where t_{ik} represent the relative, or in Newtonian dynamics, the mechanical, strains. And even in Maxwell electrodynamics the existence of charges can be accounted for only by taking account of these strains. More generally, Mie has shown that they cannot be accounted for by any system of electrodynamics in which the world-tensor is zero. The author, however, in a detailed relativistic analysis of the question shows that, in virtue of the fact that the world-tensor $\Sigma[4, 1]T_{ii}$, although it can never vanish, is an invariant of the Lorentz transformation, Schottky's equation, $L = -(U - U_0)$, is approximately true, in that the solution in ascending powers of $(q/c)^2$, where c is the speed of light, and $(q/c)^4$ and higher powers are neglected, will differ from the true value of the kinetic energy only by an amount of the order of $(q/c)^4$. No such rigid proof of the equation $E = 2(U - U_0)$ is obtainable, but the final conclusion of the analysis is that Schottky's propositions hold good as approximations in so far as the motions of the particles can be regarded as quasi-stationary and $(q/c)^4$ taken as negligible compared with $(q/c)^2$. **G. W. de T.**

911. *Two Simple Lecture Experiments to Demonstrate the "Ion-wind."* **V. F. Hess.** (Phys. Zeits. 21. pp. 510–513, Oct. 1, 1920.)—[For the previous work on this subject, see Abs. 864 (1918) and 1315 (1920).] The author refers to the work of S. Ratner [see Abs. 65 (1917)] on the ion-wind produced in the neighbourhood of radio-active substances. A description follows of two simple methods of demonstrating this phenomenon when the ions are produced either by a-particles or by hot bodies. The existence of the wind is in the first experiment made apparent by means of thin jets of sal-ammoniac "smoke," streaming between the potential plates which control the movements of the ions and ion-carriers. The jets of "smoke" are deflected quite perceptibly in the direction of the wind. In the second method a light Al leaf is used as the indicator. By these means the author has been able to obtain quantitative results in good agreement with those of other observers using more elaborate methods. A. B. W.

912. *Electrification of Mercury by Friction.* **E. Perucca.** (N. Cimento, 21. pp. 34–50, Jan., 1921.)—A freshly made surface of mercury is strongly electrified positively if placed in contact with glass, paraffin, sealing wax, ebonite, wool, etc. [see Abs. 92 (1918)], but, after a time, which varies between certain limits, the mercury surface loses its positive charge, passes through a neutral stage, and then acquires a negative charge which gradually increases to a limiting value. This phenomenon appears to be connected with the observed variation with time of the capillary constant of mercury, and also with the variation with time of the optical behaviour of the surface in respect to reflection [see Abs. 717 (1919)]. In the present paper the conditions under which the author has carried out his experiments are described and the results obtained stated. He also endeavours to co-ordinate the results now obtained with those of other experimenters. The discussion of the cause of the phenomenon is deferred and will be dealt with in another communication. A. E. G.

DISCHARGE AND OSCILLATIONS.

913. *Electric Figures.* **M. Toepler.** (Phys. Zeits. 22. p. 59, Jan. 15, 1921.)—Two tin-foil strips with semicircular ends at a distance *d* apart are placed in line on a glass plate, and a photographic plate is placed on top with the film uppermost, alcohol filling the rest of the space between the plates. A high potential is suddenly applied between the outer ends of the tin-foil strips. This potential must not be high enough to produce a discharge through the alcohol. The field between the inner ends of the tin-foil strips at sufficiently high potentials produces electric figures, a sketch of which is given. The effects observed with different distances *d* and different voltages (0·35 to 1·0 cm., and 32,000 to 44,000 volts respectively) are described. A. W.

914. *Photoelectric Conductivity and Phosphorescence.* **B. Gudden** and **R. Pohl.** (Zeits. f. Physik, 3. 2. pp. 98–103, 1920.)—Using a special preparation of Ca-Bi-Na phosphores (*CaBiNa-Phosphor*), the authors obtained results which (plotting current per unit illumination as ordinate against wave-length 250–550 $\mu\mu$ as abscissa) give curves with two maxima, somewhat resembling those due to Lenard. Three fields were used, viz. 6400, 11,000, and 16,000 volts per cm. E. H. B.

915. *Photoelectric Conductivity of Diamonds.* **B. Gudden** and **R. Pohl.** (Zeits. f. Physik, 3. 2. pp. 123–129, 1920.)—This paper gives slightly fuller details of work previously described. [See also Abs. 502 (1921).] A. W.

916. *Electron Emission from Hot Bodies; Departures from the Maxwell Velocity Distribution.* **S. L. Ting.** (Roy. Soc., Proc. 98. pp. 374–394, Feb. 2, 1921.)—Experiments with tungsten and platinum wires and strips show that whilst Maxwell's law of velocity distribution may be an ideal which is realised in some cases, it is frequently departed from in practice. A very common type of emission appears to be one in which the distribution of velocity is in close agreement with Maxwell's law, except that the average kinetic energy is about twice that which would correspond to the temperature of the source. Some of the results obtained with Pt, however, exhibit velocity distributions which are not at all of the Maxwell type. It may be that the Maxwell type would hold for an ideal flat surface of pure metal, and that these variants from it are conditioned by effects of absorbed gas or the like. Some support for such a view may be drawn from certain hysteresis effects described. Further experiments will be undertaken to investigate this possible connection between the changes in velocity distribution and gas actions. [See Abs. 1825 (1908).] A. W.

917. *Current Oscillations in Hot-kathode Tube Circuits.* **W. Schottky** and **C. A. Hartmann.** (Zeits. f. Physik, 2. 3. p. 206, 1920.)—A theoretical investigation brought out that current oscillations will be set up in an oscillatory circuit connected to a hot-kathode tube. The presence of the effect has been verified by experiment, but its magnitude is not so great as was expected. The value calculated for the electronic charge is not constant under all conditions, but approaches the standard value as the frequency of the oscillations diminishes. [See also Abs. 180 (1920).] G. E. A.

918. *Photometry of the Afterglow in Active Nitrogen.* **E. v. Angerer.** (Phys. Zeits. 22. pp. 97–102, Feb. 15, 1921.)—A method is described, using a photoelectric cell, by means of which light of small intensity, varying with the time, can be measured from second to second. With this method the after-action of the photoelectric cell could be neglected. The method was employed to investigate the rate of diminution of the afterglow in active nitrogen, and the results obtained show that the square root of the intensity of the afterglow is nearly inversely proportional to the time. [See Abs. 1234 (1910).] A. W.

919. *Afterglow of Active Nitrogen.* **J. Zenneck.** (Phys. Zeits. 22. pp. 102–103, Feb. 15, 1921.)—Describes an arrangement for demonstrating the afterglow in active nitrogen by means of the electrodeless ring discharge. A large glass bulb, of diameter 46·5 cm., was filled with nitrogen by E. v. Angerer [see Abs. 1234 (1910)]. This bulb was encircled by a wire ring 47·5 cm. in diameter, whose ends were joined to two condensers of 20,000 cm. capacity, the other terminals of the condensers being connected to an enclosed spark-gap. The latter was provided with magnesium balls of about 2 cm. diameter placed about 3·5 cm. apart. The power supply to the condenser circuit was from a resonance spark coil with fairly loose coupling between the primary and secondary coils; the primary was fed from an a.c. machine regulated so that only a few sparks per sec. occurred at the spark-gap. When the discharge passed a luminous ring could be seen in the bulb, with intensity decreasing towards the centre. If then the supply to the coil was cut off, the whole of the bulb was filled with an orange-yellow glow of such intensity and persistence, that its spectrum could be easily seen with a pocket spectroscope for about half a minute. As the glow died away its colour changed to a green-yellow. The spectrum is of the same character as observed by

Fowler and Strutt [Abs. 1339 (1911)] for active nitrogen. Calculation of the field strength within the bulb gave a value of about 82 volts/cm. A. W.

920. *Primary and Secondary Electric Figures.* **M. Toepler.** (Phys. Zeits. 22. pp. 78–80, Feb. 1, 1921.)—Describes, with diagrams, the characteristic features of electric figures obtained in a similar manner to that described by Mikola [Abs. 666 (1917)]. In the present work two photographic plates are used with their films apart. The lower film is separated from a metal plate by insulating material so as to leave a small air space. The discharge point is brought near the centre of the film on the upper plate. The features of the primary figures obtained on the lower plate and of the secondary figures on the upper plate are discussed. A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

921. *New Thermo-element for Spectrum Radiation Measurements.* **W. Voege.** (Phys. Zeits. 22. pp. 119–120, Feb. 15, 1921.)—Details are given of a thermo-element made for the author by the firm of Carl Zeiss. The instrument was specially designed with a variable "slit" aperture so as to be especially suitable for spectrum analysis. Results are tabulated indicating its sensitiveness with various settings of the slit. A. B. W.

922. *Electrical Measurements at Ultraradio Frequencies.* **G. C. Southworth.** (Radio Rev. 2. pp. 25–31, Jan., 1921.)—In a previous paper [Abs. 128 (1921)] sources of alternating currents of ultraradio frequencies were described. Methods were also given for measuring the length of standing waves produced on a parallel-wire circuit when excited by a very high-frequency source. The present paper gives a brief outline of the theory of such circuits, and shows how such circuits can be used for determining with considerable accuracy the values of unknown inductances and capacities. The methods are similar to those used by Drude in measuring the dielectric constant of liquids, but are simpler and more accurate because of the use of continuous oscillations. A. W.

923. *A Method of Testing Triode Vacuum Tubes.* **E. V. Appleton.** (Cambridge Phil. Soc., Proc. 20. pp. 239–242, Jan., 1921.)—A circuit is described which affords a simple and convenient method of measuring the slope of the voltage-current characteristic of a thermionic valve. This circuit is illustrated and a proof of the formula used is given. B. J. L.

924. *Thermo-couple as Alternating-Current Ammeter.* **W. Gerlach.** (Phys. Zeits. 21. pp. 550–551, Oct. 15, 1920.)—Describes a method for calibrating a thermo-element for use as an a.c. ammeter. J. W. T. W.

925. *Electrical Resistance of Nickel Steels.* **M. A. Portevin.** (Comptes Rendus, 172. pp. 445–447, Feb. 21, 1921.)—Gives the results of the determination of the resistivity of a series of nickel steels containing 7 to 15 % Ni and 0·3–0·8 % carbon after heating to 1000° C., followed by slow cooling during 4 to 5 hours, and after heating to 1300° C., followed by very slow cooling during about 3 days. These determinations were made in order to investigate certain differences in resistivity of steels within this range, previously published by the author and by Boudouard, and the results obtained show that with the first-mentioned rate of cooling the resistance is from 10 to 40 % higher than in the case of the specimens very slowly cooled. The latter results agree with those previously published by Boudouard. C. O. B.

926. *Thomson-Effect and Thermal Conduction in Metals.* **E. H. Hall.** (Nat. Acad. Sci., Proc. 6. pp. 613–621, Oct., 1920.)—*Thomson-effect.*—The dual electric conduction theory proposed by the author [Abs. 1003 (1920)] leads to values of the temperature coefficient of thermal conductivity which are obviously too high. A provisional modification is therefore suggested, viz. to write $\lambda' = \lambda'_0 + sRT$, where s is a constant, depending on the nature of the metal, but always greater than 2·5, the value previously assigned. This change necessitates revision of the tables in the paper on the Thomson-effect, but the general conclusions remain the same.

Thermal conductivity.—The author deduces a value for the thermal conductivity θ on his dual hypothesis, namely:

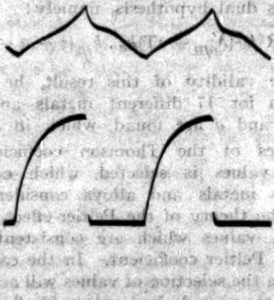
$$\theta = R^2/e^2(\lambda'_{0/R} + sT)k_a \cdot k_{f/k}(s + q - 1\cdot5).$$

In order to test the validity of this result, he uses experimentally determined constants for 17 different metals and alloys. By trial, values of λ'_0 s, $k_{f/k}$, and q are found, which in combination account for Bridgman's values of the Thomson coefficient. From these a smaller number of values is selected, which conform with known values of θ for the metals and alloys considered. It will further be necessary, when the theory of the Peltier-effect has been developed, to select from these, values which are consistent with experimental determinations of the Peltier coefficient. In the case of Bi, Co, Fe, Ni, Pd, Pt, Sn, Te, and Zn the selection of values will account for Bridgman's σ, and at the same time give desired values for θ_0 and θ_{100}. There is a discrepancy of 6–10 % in the calculated ratio θ_0/θ_{100} for Ag, Al, Cu, and Au, while Cd apparently does not fit in with the theory. L. L.

927. *X-ray Work at Schenectady.* **W. D. Coolidge.** (Röntgen Soc., J. 17. pp. 23–29, Jan., 1921.)—Deals with the research work carried out at the General Electric Co.'s laboratory, so far as this applies to the production of the lecturer's X-ray tube. A detailed description is given of the methods used for the production from wolframite of ductile tungsten for the manufacture of the electrodes. The high temperatures needed render the use of crucibles impossible, and electrical methods of heating are used. Attention is then devoted to the methods used to solder the tungsten to the copper target; the success of the tube is greatly dependent on this, since, otherwise, vaporisation of the copper gives rise to variations of vacuum. Experimental results of the action of various residual gases on the tube's working are described.

Cracking of the glass containers with overloads was overcome by immersing the tube in oil. Trouble was also experienced owing to the melting of the Al kathodes; these were therefore replaced by tungsten. Reference is made to the assistance obtained from Langmuir's methods of obtaining high vacua. A demonstration was given of the effect of secondary electron emission from the anode, which, whilst pronounced, has little practical disadvantage. The blowing of the glass containers is nowadays carried out by machinery, operated by girls. A description was then given of modern types of Coolidge tubes. B. J. L.

928. *Mechanism of the Hammer-break Coil Interrupter.* **J. K. A. W. Salomonson.** (K. Akad. Amsterdam, Proc. 23. 6. pp. 869–876, 1921.)—An account of a research on the attraction by the electromagnet on the armature during the working of the apparatus. As an indicator for the attraction, the author used the number of lines of force passing through the armature at each moment; this was measured by means of Déguisne's oscillographic method [see Abs. 1334 (1910)]. The interrupter had a horizontal horseshoe magnet with cores of Swedish iron screwed into a yoke; the armature was screwed to a strong steel spring, and had a frequency of 47. The working current flowed during half of each period. The middle of the armature was wound with 40 turns of wire connected to fixed terminals by two large spiral coils. While the interrupter was in action, oscillograms were taken of the current in the electromagnet (see Fig., second graph) and the magnetic density in the armature (top graph). The vibration period is divided into four nearly equal parts: during the first two the current is flowing; during the second and third the armature is moving towards the electromagnet. The flux density in the armature during "make" may be calculated from a formula which takes account of the effect of inductance, and assumes a simple harmonic variation in the total length of the air-gap. The graph obtained from the formula is similar to the ascending portion of the oscillogram wave; a quantitative explanation is not, as yet, possible for the descending part of the curve. When a string galvanometer is employed as oscillograph to determine the mode of variation of the lines of force in an iron path or air-gap, a few insulated windings are laid round the iron or a small coil is placed in the air-gap and connected to the terminals of a condenser in parallel with the string galvanometer. It is shown analytically that, when the circuit has large time-constants, the induction is proportional to the p.d. across the condenser. An oscillogram bears this out, the ascending and descending portions approximating to straight lines. G. E. A.



929. *Simple Single-String Electrometer.* **L. Grebe.** (Zeits. f. Physik, 3. 5. p. 329, 1920.)—On a plate of brass about 6 cm. long by 1 cm. wide two little brass blocks are soldered in oblique position, on these is fixed by an insulator, in the form of a bent bow, a quartz or glass fibre, about 0·02 mm. diameter. The fibre is made conducting by chloride of calcium solution, and is set with the plane of its curve parallel to the brass plate, and about 1 mm. distant from it. The whole system is insulated and fixed in a case. On charging it the fibre changes curvature, and the shift of its centre is read by a microscope. It has about the same sensitiveness as the Wulf two-string electrometer, and is suitable for ionisation measurements with radium and X-ray researches. E. H. B.

930. *Quadrant Electrometer.* **G. Kirsch.** (Phys. Zeits. 22. pp. 75–76, Feb. 1, 1921.)—When the quadrant electrometer is used to measure potentials, the max. sensitiveness usually obtained is of the order of 4000 scale divisions per volt. It is here shown that by using the instrument to measure, for example, ionisation currents, and therefore increasing charges, the above sensitiveness can be increased about 10 times if the directive force on the needle is sufficiently diminished. In these measurements the angular velocity of the needle is determined. A. W.

931. *Instrument for Measuring Low Susceptibilities.* **E. Wilson.** (Roy. Soc., Proc. 98. pp. 274–284, Jan. 3, 1921.)—The *apparatus* was designed with the object of being portable and capable of measuring susceptibility over a wide range of magnetic force. Two ring electromagnets are employed; one is vertical, and the specimen hangs between its poles; the other is horizontal, and situated at a higher level than the first, and a moving coil is suspended in its pole gap. This coil is rigidly connected to a horizontal beam above it; the specimen hangs from one end of the beam, and there is a counterpoise at the other side of the suspending strip. When currents flow through the electromagnets and the coil, the deflection of the latter tends to pull the specimen out of the field of the lower magnet. The coil is brought back to the position for zero torsion by displacing the lower magnet on slide rails. The force exerted by the magnet on the specimen is then a maximum for a given current, and the mass susceptibility is calculated from the currents in the magnets and coil and the constant of the instrument. Measurements of the susceptibilities of a number of substances are detailed. [See also Abs. 621 (1920).] G. E. A.

932. *New X-ray Tube enabling Reduced Exposure to be used.* **A. Hadding.** (Zeits. f. Physik, 3. 5. pp. 369–371, 1920.)—In the method devised by Debye and Scherrer [see Abs. 380 (1918)] for the X-ray analysis of crystals in powdered form, exposures varying from 3 to 20 hours are necessary to obtain a good X-ray spectrum photograph when a Coolidge tube is used. The author now describes a tube by means of which a good spectrum photograph can be obtained in 15 to 45 minutes. The tube is of the Lilienfeld type, consisting of a thick-walled bomb-shaped vessel, into which the electrodes are fitted. The kathode is mounted in a porcelain high-tension insulator, which fits like a cap over one end of the vessel. Both electrodes are water-cooled. The antikathode is disposed opposite a small Al window, which permits of soft radiation passing effectively out of the tube. With applied voltages of 32, 34–37, and 40 kilovolts, the currents through the tube are respectively 5, 10–20, 20 milliamps. Further increases of h.t. voltage produce no further increase of current. A. B. W.

933. *Kathode-ray Oscillograph; Modified Braun-tube Arrangement.* **A. Dufour.** (J. de Physique et le Radium, 1. pp. 147–160, Nov., 1920.

Paper read before the Soc. franç. de Physique.)—A description is given of a modification of the Braun kathode-ray oscillograph. The apparatus has been designed for use at any frequency up to several million cycles per sec. The arrangements for high and low frequencies are slightly different. The apparatus is designed to show the actual wave-form of an oscillation. In order to accomplish this at radio frequencies, the motion of the kathode beam due to voltage or current is superposed on an oscillation varying at a much slower rate, *i.e.*, the radiofrequency oscillation undergoes a form of modulation. This is accomplished by the use of three magnetic fields, two of which are at right angles to the third. The voltage used on the tube for producing kathode rays is 60,000, and the current from 2 to 10 milliamps. This is obtained either from an electrostatic machine or a transformer. The construction is so arranged that several photographic records (plates) can be secured without opening the apparatus. The plates are contained in the base of the apparatus, and a vacuum pump is fitted so that the vacuum necessary for the production of kathode rays can be obtained.

N. W. M.

934. *Automatic Potential Regulator for Currents in Vacuo.* **A. Rüttenauer.** (Zeits. techn. Physik, 2. 3. pp. 71–73, 1921.)—In many measurements *in vacuo*, such as those on canal rays, it is necessary that the potential of the discharge tube should be kept exactly constant. An apparatus is here described which can be arranged for the potential desired, and then can be relied upon to correct automatically any potential alteration. A schematic diagram and full details of the method of employing the regulator is given. A. E. G.

ALTERNATING CURRENTS AND MAGNETISM.

935. *Electronic Theory of Conductivity of Metals in a Magnetic Field.* **O. M. Corbino.** (Accad. Lincei, Atti, 29. pp. 282–285, Nov. 7, 1920.)—It is concluded that the phenomena which occur during the passage of heat or of electricity in metals cannot be satisfactorily explained by a theory which takes count of only one kind of electron; in all this field of phenomena the dualistic theory has the advantage. On this account, although the existence of free positive electrons has not yet been proved, they constitute provisionally an indispensable element in any complete explanation of the phenomena of metallic conductivity and of the effects of the magnetic field. A. E. G.

936. *Thermal Analogy of the Oersted-Ampère Effect and the Electronic Theory of Metals.* **O. M. Corbino.** (Accad. Lincei, Atti, 29. (ii) pp. 335–339, Dec., 1920.)—If there exist a thermal analogy of the Oersted-effect it ought to be possible to show that a disc, through which flows a radial current of heat, will exhibit a tendency to rotate when subjected to the action of a magnetic field at right angles to its plane. The object of the present paper is to consider the probability of being able to demonstrate such an effect and to investigate the question in its relation to the electronic theory of conductivity of metals. [See also preceding Abs.]

A. E. G.

937. *Galvanomagnetic Effects.* **A. Sellerio.** (N. Cimento, 20. pp. 51–94, Sept.–Oct., 1920.)—Finds the phenomena presented by bismuth in a galvanomagnetic field to be analysable into three components:

(*a*) The ordinary Hall-effect, transverse and proportional to H; (*b*) an axial effect, proportional to H and directed along the lines of force; and (*c*) a disturbing effect proportional to H^2, with angular relations of the order of a harmonic of the two former. To the last mentioned the known asymmetry of the Hall-effect is to be traced. A. D.

938. *Magnetism and Atomic Structure.* **A. E. Oxley.** (Roy. Soc., Proc. 98. pp. 264–274, Jan. 3, 1921. Abstract of paper read before the British Assoc., Cardiff, 1920.)—The paper aims at an interpretation of the electron structure of matter which is compatible with the results of recent magnetic investigations. The behaviour of diamagnetic and paramagnetic crystals in a magnetic field suggests a spacial distribution of electron orbits round the nucleus. In un-ionised media the coupling force between the units of the crystalline structure is magnetic induction, and the coupling systems are pairs of electron orbits. It is probable that the Laplace intrinsic pressure in liquids is due to electrostatic doublets of atomic dimensions. Crystallisation sets up directional stresses due to highly localised magnetic doublets. The presence of the latter suggests either that the conventional electron moves in an orbit very small compared with atomic dimensions, or that the electron itself is a complex unit endowed with specific magnetic and electrostatic properties, *i.e.*, the electron is also a magneton. G. E. A.

939. *Mathematical View of Fundamental Magnetic Phenomena.* **J. Kelen.** (Elektrot. u. Maschinenbau, 38. pp. 466–470, Oct. 3, 1920.) —Starting with molecular magnets which are acted on by friction, a simple equation of equilibrium is written down for an element which has been deflected through a given angle by the application of a magnetic field. Assuming non-homogeneous material and non-uniform friction, the probability curve is introduced, and equations are obtained which represent the magnetisation of a body from the neutral condition, and cyclic magnetisation, and finally the area of the hysteresis curve. Curves are plotted along with the corresponding ones from Steinmetz's equation to show the degree of approximation attained. G. E. A.

940. *Magnetic Phenomena in Paramagnetic Salts.* **W. Lenz.** (Phys. Zeits. 21. pp. 613–615, Nov. 1 and 15, 1920. Paper read before the Naturforscherversamml., Nauheim, Sept., 1920.)—The solid paramagnetic salts, like the paramagnetic gases, conform to Curie's law. Weiss's explanation of this, based on the assumption that the molecules of the crystal are as free to rotate as those of the gas, was found to be unsatisfactory. His second hypothesis, that the elementary magnets execute vibrations about a fixed position of equilibrium, leads to Curie's law, but is otherwise defective. The assumption of free rotation appears to be indispensable, but the properties of crystalline structure present objections to the view that either the molecules or the atoms are capable of free rotation. The author suggests, by inference from the properties of magnetite and pyrrhotine, that it may be the direction of magnetisation which changes, and not the position of the magnet itself. Going on this assumption, Curie's law is deduced. G. E. A.

941. *Magnetic Mechanical Analysis of Steel.* **R. Hadfield, S. R. Williams,** and **I. S. Bowen.** (Roy. Soc., Proc. 98. pp. 297–302, Jan. 3, 1921.)—The material consisted of six manganese steel rods 76 cm. long and 0·95 cm. in diam., which contained 1·25 C, 0·43 Si, and 12·20 % Mn. All the bars were kept at 1000° C. for 5 minutes, and were then quenched in cold water. Bars 1, 5, and 6 were annealed in a closed pipe at 500° for 68 hours. After a rough test, rods Nos. 2 and 5 were selected to represent the non-magnetic and magnetic types respectively. Williams' method [see Abs. 1110 (1912)] was employed to determine the Joule-effect (length change) during an increase of field from 0 to 3000 gauss. Rod No. 5 gave an increment in length, which increased with the field, but no length change was detected in rod No. 2. The rods were next tested for the effect of tension on magnetisation (Villari-effect), using at the centre of the rod a small coil connected to a ballistic galvanometer; a method is explained which gave I proportional to the throw of the galvanometer needle. Graphs exhibit the relation of I to H with no tension, and the change in I with H when the rod is under 350 kg. tension. Rod No. 2 did not show any change in I when under tension; the slight magnetic qualities in this rod were found to be due to the oxidised surface layer. [See also Abs. 156 (1920).] G. E. A.

942. *Horizontal Intensity Measurement by Dieterici Method.* **E. Mauz.** (Phys. Zeits. 22. pp. 11–15, Jan. 1, 1921.)—The Dieterici electrical method of measuring H [see Abs. 114 (1918)] is tested with regard to the obtainable accuracy. The period of vibration of a magnet is measured when the earth's field is first increased and then decreased by a known amount, the change being made by passing a current through windings on the instrument. The periods are corrected for torsion of the suspension and for magnetic induction in the vibrator. The current windings are arranged in two sets, each containing three layers of three turns, and the middle wires of the sets are at a distance equal to the radius of the winding, and the vibrator lies between the two coils. With 10-minute observations of the periods the values of H agree to 3 parts in 1000; for two series of observations given the values of H were 0·19941 and 0·19925. G. E. A.

943. *Heusler Alloys with High Iron Content.* **O. v. Auwers.** (Ann. d. Physik, 63. 9. pp. 867–899, Dec. 28, 1920.)—The instruments employed were Richarz's magnetoscope, Du Bois' balance, and Tobusch's magnetometer. The last instrument had been used only for comparative measurements [see Abs. 1401 (1908)], and the author gives its theory and works out a formula to give the intensity of magnetisation in terms of the deflection. The test rod is placed in a vertical coil at a given distance from an astatic needle system; the length of the bar is so chosen that its pole distance is equal to the distance between the astatic needles, and the poles are adjusted to the same level as the needles. Details are given of various tests of the working formula and of the apparatus. The material consisted of four bars containing about 9 % Al, 17 Mn, 59 Cu, and Fe varying from 13·5 to 18·1 %. Groups of curves for two of the bars exhibit the changes in magnetisation and coercive force during thermal ageing, which extended to 300 hours. It is concluded that, as the result of such large additions of iron, these Al-Mn bronzes become neither more magnetic nor less magnetic than the Heusler alloy would be without the iron. G. E. A.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

944. *Periodic Relation between the Atomic Weights of the Elements.* V. *Calculation of Rydberg's Constant.* **K. Fehrle.** (Phys. Zeits. 22. pp. 60–62, Jan. 15, 1921.)—Theory developed in earlier papers [see Abs. 737 (1921)] allows a calculation to be made of Rydberg's constant. The value found is $1 \cdot 09 \times 10^5$, which is in good agreement with the experimental value. A. W.

945. *Properties of Plastic Crystals of Ammonium Nitrate.* **W. N. Bond.** (Phil. Mag. 41. pp. 1–21, Jan., 1921.)—Various forms of ammonium nitrate crystals and their conditions of formation and stability are enumerated. Experiments on the behaviour of crystals under stress with varied loadings are described. The crystals are stressed as cantilevers, as beams, and in simple tension, only indefinite results being obtained in the last case. The influence of time on the recovery from the effects of stress is studied and the results are illustrated in graphs. The change of form is shown to be characteristic of plasticity and not due to simple viscous flow. The curved forms of the crystals bent under central loads are compared diagrammatically with those of celluloid and lead and with the theoretical elastic curves. Bent crystals are examined between crossed nicols, and it is found that the extinction lines appear always to be inclined at roughly 45° in either direction to the radius of curvature of the crystal. The optical properties show, on the whole, that the structure is but little changed by bending. The experimental results are discussed in relation to changes in internal structure, and it is shown almost beyond doubt, that whilst slight longitudinal slip may occur, a rotation or orientation of the atomic groups forms at least part of the change accompanying plastic bending. A. B. C. L.

946. *The Chemical Affinity of the Noble Gases.* **F. Skaupy.** (Zeits. f. Physik, 3. 5. pp. 408–411, 1920.)—Kossel's valency theory, which places stable electronic arrangement for the noble gases as a central consideration, and ascribes many reactions to the inclination towards such arrangement, does not appear to afford sufficient explanation for the indifference of the noble gases. Especially does this difficulty arise in conceptions regarding the constitution of the halogen molecules, where two halogen atoms unite, with simultaneous formation of two stable noble gas configurations. From this standpoint, it would appear that an appreciable affinity must be exerted between the atoms of noble gases and those of the halogens. In consequence the assumption must be made, that a noble gas atom can unite with a halogen atom to form a diatomic molecule, so that an electron of the noble gas enters into the incomplete electronic cube of the halogen atom without disturbing its stable configuration, and also affording a second noble-gas configuration. The affinity of such a combination is discussed in the paper. It is concluded that the indifference of the noble gases may be simply explained; namely, that in all cases where opportunity for the noble-gas compound is afforded, simultaneously the other atoms present in the reaction mixture have the opportunity of forming still more stable molecules among themselves. Methods for the experimental study of the equilibrium laws are then discussed, *e.g.*, vapour density determinations of noble gas and halogen mixtures at high temperatures to avoid the reaction inertia at low temperatures, measurement of light absorption, and spectral phenomena. Evidence of activity appears to be afforded by these methods. The same considerations are extended to other electro-negative elements. The influence of the presence of noble gases upon the absorption of nitrogen by calcium carbide may be explained by the intermediate formation of noble-gas compounds. This line of research is recommended for the further study of affinity problems of the noble gases. **H. H. Ho.**

947. *Ammonia Synthesis at Very High Pressures.* **G. Claude.** (Comptes Rendus, 172. pp. 442–444, Feb. 21, 1921.)—Remarks on two demonstrations of the process and on progress made [see Abs. 758 (1920)]. In the demonstrations liquid ammonia was produced at the rate of 70 litres per hour with the aid of 4 tubular catalysers, 2 in parallel and 2 in series; no particulars are given. Electrolytic hydrogen was used. In the new apparatus for 5 tons of ammonia per day, the compression is effected in two (previously 3) stages, first to 100 atmos., then to 900 atmos. There is hardly any smell of ammonia. It is stated that enormous quantities of heat are liberated by the hyper-compression in smaller apparatus; how the heat is eliminated is not explained, nor is there any description of the apparatus, made with the co-operation of Le Rouge, Schideler, and Parer. **H. B.**

948. *Permeability of Glass to Iodine and Bromine Vapours.* **J. B. Firth.** (Chem. Soc. J., Trans. 117. pp. 1602–1603, Dec., 1920.)—The results of the experiments here described indicate that it is possible for iodine to pass through a thin glass partition under certain conditions, but the rate of diffusion is exceedingly slow, about nine years being occupied in traversing glass 0·2 mm. in thickness. There is no evidence of the passage of bromine through glass of similar thickness, even after 9½ years.

These results do not support the explanation advanced by Zengelis for the loss in weight observed in Landolt's experiments, since the time taken in the cases where a positive result has been obtained is considerably greater than the duration of Landolt's experiments, in which, also, the glass used was much thicker than that of the author's tests. **T. H. P.**

949. *Surface Tension of certain Soap Solutions and their Emulsifying Powers.* **M. G. White and J. W. Marden.** (J. Phys. Chem. 24. pp. 617–629, Nov., 1920.)—Accurate measurements have been made of the surface tensions of sodium stearate and palmitate solutions by the capillarity method. It is found that, unlike solutions of sodium hydroxide and many salts, soap solutions diminish in surface tension as they increase in concentration. **T. H. P.**

950. *Relation between Brinell Hardness-Number and the Grain Size of Annealed Carbon Steels.* **H. S. Rawdon and E. Jimeno-Gil.** (Bureau of Standards, Bull. 16. pp. 557–593 [Sci. Papers, No. 397], 1920.)—Contains the results of an investigation during which the Brinell hardness was determined for five steels varying in carbon content from 0·07 to 1·12 % after heat treatment arranged to produce wide variations in grain size. Upon heating for 6-hour periods no very appreciable increase in grain size occurs until the *Ac* transformation has occurred. The change in grain size often appears to be a very abrupt one, taking place within a narrow range of temperature. Two methods were used for obtaining the Brinell numbers—the standard method for the average hardness of the material, and the micro-Brinell apparatus which was developed by the Ordnance Department of the U.S. Army and in which a load of 15 kg. for 30 secs. upon a ball $\frac{1}{16}$ inch in diameter is used for the hardness of individual crystals or small aggregates. The results obtained show no appreciable or consistent difference between the hardness of small groups of crystals and the average hardness for the steels investigated. The micrographic examination indicates that there is no simple and direct relation between grain size and Brinell number for carbon steels. A very pronounced increase in grain size is usually accompanied by a decrease in hardness, but on the whole, grain size appears to be a factor of minor importance in determining the hardness. The general effect of heating the steel, followed by cooling, is to harden it appreciably. This increase is noticeable in spite of a pronounced drop in hardness which accompanies an abrupt increase in grain size. This tendency toward hardening upon heating is not shown by low-carbon steels to any extent, thus suggesting that this change in hardness is not a function of the grain size. The rate at which steels are cooled, and consequently the structural condition of the hardening constituent, affects the hardness much more than any other factor. The hardness measurements upon material in which a pronounced differential grain growth has been produced by low-temperature annealing after straining the metal are in general accord with the results obtained upon the same steels in which the grain was coarsened by heat alone. C. O. B.

951. *Deoxidation of Steel with Hydrogen.* **J. H. Whiteley.** (Iron and Steel Inst., J. **102.** pp. 143–156; Corres., 157, 1920.)—As it was found to be impossible to remove the banded structure which was supposed to be due to the presence of oxide, in a section of steel, by heating in dry hydrogen for several hours at temperatures below 950°, it was decided to investigate the action of hydrogen on visible particles of oxide and to ascertain the speed at which such oxide could be reduced in the metal. Experiments are described in which a sample of "Armco" iron that contained numerous particles of iron oxide and iron oxide-sulphide eutectic was used. Various tests for the identification of oxide and sulphide are given including acid etching, heat tinting, tartar emetic gelatin, and reduction in hydrogen. Two series of reduction tests are described, the first with sections $\frac{1}{8}$ in. thick and the second with strips $\frac{1}{400}$ in. thick. The results show that oxide is removed very slowly below 950° C. and as the temperature is raised the speed increases. The strips did not appear to be entirely deoxided in one hour at any temperature below 1300° C. With thin turnings the speed of deoxidation is decidedly quicker, probably owing to the presence of numerous cracks and fissures in them. It is shown that it is possible for one steel to be decarburised and another carburised when heated under the same conditions in an atmosphere of hydrogen.

The experiments show that if oxygen, as oxide, is to be correctly determined in steel by combustion in hydrogen, a high temperature 1000° to 1200° C. is required. The finest drillings or turnings should be used if long heating is to be avoided, and the possibility of CO and CO_2 being evolved should not be overlooked. C. O. B.

952. *The Hardening of Carbon Steel; Influence of the Rate of Cooling.* **A. M. Portevin** and **M. Garvin.** (Bull, Soc. d'Encouragement, 132. pp. 198–226, March–April, and pp. 297–346, May–June, 1920. Am. Soc. Mech. Eng., J. 42. pp. 580–581, Oct., 1920.—Abstract.)—A *résumé* of the work of the authors, with illustrated description of the apparatus. The main conclusions were given in 1917 [see Abs. 1191 (1917)]; references are made to subsequent papers [see Abs. 119 (1918), 802 (1919), and 271 (1920)]. The authors emphasise the importance of the size of the specimen and the position of the point under investigation in the specimen (surface or interior); disregard of these considerations explains many discrepant statements. H. B.

953. *Anomalous Osmosis with Gold-beater's Skin Membranes. Chloride Solutions in the Presence of Acids and Basis.* **F. E. Bartell** and **O. E. Madison.** (J. Phys. Chem. 24. pp. 593–607, Nov., 1920.)—The osmosis of salt solutions through membranes of gold-beater's skin is affected to a notable extent by the presence of acid or alkali. Details are given for LiCl, NaCl, KCl, $MgCl_2$, $BaCl_2$, $AlCl_3$, $ThCl_4$, over the range from an acidity of 0·1 M to an alkalinity of 0·1 M. Thorium and aluminium chlorides show maxima of osmosis when the system is alkaline throughout (0·0001 M); magnesium and barium chlorides give maxima at about 0·001 M acidity, and LiCl, NaCl, and KCl also give slight maxima at 0·001 M acidity. T. M. L.

954. *Transference Numbers of Liquid Amalgams.* **F. Skaupy.** (Zeits. f. Physik, 3. 3. pp. 178–181, 1920.)—Lewis, Adams, and Lanman [Abs. 265 (1916)] observed that in amalgams of sodium and potassium the alkali metal travelled to the anode. The author had in 1914 suggested an explanation of similar experiments by Kinsky. He now shows that the electronic friction of Lewis would involve special assumptions, and that the phenomenon can simply be regarded as a displacement. When the current passes through alkali amalgams the alkali concentration at the anode is increased, because the positive mercury ions, in migrating to the kathode, press the other part of the liquid (containing the amalgam) over to the anode. The transference number should be proportional to the proportion of the dissolved metal and should, for a given concentration, be the same for different metals under certain conditions. It is in accord with the formula deduced that the concentration of potassium at the anode is greater than that of sodium; pure lead and tin would probably concentrate at the kathode [see Abs. 740 (1921)]. H. B.

955. *Molecular Volumes of the Alkali Halides.* **K. Fajans** and **H. Grimm.** (Zeits. f. Physik, 2. 4. pp. 299–308, 1920.)—The relation between the molecular volume, y, of a halide of a given alkali metal, and the molecular volume, x, of the same halide of another alkali metal is found to be of the form $y = \alpha x + a$. Thus, for corresponding halides of potassium and sodium, $V_{KX} = 1{\cdot}130\ V_{NaX} + 6{\cdot}95$. Values of α and a are calculated from the densities of lithium, sodium, potassium, and rubidium chlorides, bromides and iodides determined by Baxter and Wallace, and the numbers thus found may be employed for calculating the molecular volumes of

other halides which are either unknown or inaccurately known. The accuracy of the results is about 0·1 % in the above cases, but Schröder's values for fluorides of the alkali metals (1873) appear to be less exact. The abnormal values found in the case of caesium salts are possibly connected with the crystalline forms exhibited by these salts.

The question of the actual volumes of the ions is discussed, and it is shown that the sphere of action of an ion is not a sharply defined magnitude, but is dependent on the other constituent ion. T. H. P.

956. *Conductivity of Dilute Alloys Free from Mixed Crystals ; Reply to Lichtenecker's Criticisms.* **H. C. Burger.** (Phys. Zeits. 22. pp. 28–29, Jan. 1, 1921.)—This paper is a reply to some recent criticisms by Lichtenecker of the author's work on the conductivity of dilute alloys free from mixed crystals [see Abs. 1666 (1920)]. The formulæ obtained excluded cases of zero conductivity and applied to metals only. Discrepancies for special cases are explained, and the general result is stated to be in complete agreement with that of Maxwell. The differences between the conductivities of the dilute alloy and the solvent metal are emphasised as being dependent on the shape of the particles. The formulæ are only claimed to be approximations. H. H. Ho.

957. *Thermodynamic Treatment of Concentrated Solutions, and Applications to Thallium Amalgams.* **G. N. Lewis** and **M. Randall.** (Am. Chem. Soc., J. 43. pp. 233–254, Feb., 1921.)—The investigations of the electromotive and thermal properties of thallium amalgams by Richards and Daniels [see Abs. 479 (1920)], and of the vapour pressure of mercury from the same by Hildebrand and Eastman, are used to illustrate the exact thermodynamic treatment of concentrated solutions. Partial Molal Quantities in relation to thermodynamic theory are explained and illustrated, and methods of calculation involving their use are studied. It is shown that by their use greater rapidity and precision are obtained in calculating the results than by the methods employed by Richards and Daniels. The general equations of Partial Molal Quantities are developed and applied to special cases. The calculations are used to show how the heat of solution of solid Tl and of supercooled liquid Tl in a large excess of mercury may be obtained and from these quantities the heat of fusion of Tl. The activities of Tl and of Hg in amalgams of various compositions at 20° C. and at 325° C. are given, and these values, resting upon independent measurements, are compared by simple thermodynamic methods. The effect of temperature upon the abnormality of solutions is discussed, and it is shown that the vapour pressure of amalgams at 325° may be calculated from the measurement of e.m.f. at 20° by two methods, between which two results the true value must lie. Thus in 40 % amalgam the vapour pressure was found by one method to be 1 % higher, and by the other to be 2 % lower than the measured value. A. B. C. L.

958. *Photochemical Reactions.* **W. Nernst.** (Phys. Zeits. 21. pp. 602–605, Nov. 1 and 15, 1920. Paper read before the 86. Naturforscherversamml., Nauheim, Sept., 1920.)—The author showed (*ibid.*, 24. p. 335, 1918) that, in the action of light upon a mixture of H_2 and Cl_2, assuming the primary process to consist in a dissociation of the Cl_2 into atoms and applying his heat theorem, the yield of HCl should be enormously larger than it should according to Einstein's law of equivalence. It further resulted that Einstein's law could hold only if the H were replaced by an acceptor of the Cl-atoms combining with the nascent Cl without giving rise to any disturbing reaction in the dark. According to Miss Pusch and to W. Noddack (dissertation to be published) hexahydrobenzene is such an acceptor for bromine. Noddack also found that the trichlorbromomethane CCl_3Br is an acceptor for Cl, the reaction yielding $CCl_4 + Br$; there is no reaction in the dark, and in the light the equivalence law is found to hold; the chlorine was in these experiments dissolved in the liquid acceptor. Noddack observed, however, that the presence of 1 mol. of CCl_4 did not affect the photochemical yield, whilst with 16 mols. the yield was reduced to one-half; the CCl_4 does not absorb the active rays of 410 $\mu\mu$. To account for this observation the author suggests that the activation $Cl_2 = Cl_2'$ would require 70,000 cals., and the further dissociation $Cl_2' = 2\,Cl$ about 30,000 cals., this dissociation being spontaneous owing to the exceedingly small concentration of Cl_2'; the heat of dissociation of inactivated chlorine would be about 100,000 cals. The Cl atoms might thus form the final product of the light-reaction, as previously assumed, but there would be the intermediate Cl_2' modification, endowed with very high energy. This explanation was criticised by **O. Stern,** to whom and to M. Volmer the author had referred; the further 20,000 or 30,000 cals. could not be acquired by the molecular collisions. Stern also questioned the priority of Warburg as to these problems. **Trautz** supported Nernst, mentioning manometric density determinations of chlorine made by Stäckel between 1100° and 1200°. H. B.

959. *Statistical Mechanics Applied to Chemical Kinetics.* **R. C. Tolman.** (Am. Chem. Soc., J. 42. pp. 2506–2528, Dec., 1920.)—The theory developed by Perrin [see Abs. 1104 (1919)] is applied to derive the Arrhenius equation for the temperature coefficient of reaction velocity, to obtain information as to the relation between thermal reaction velocity and photochemical reaction velocity, to provide an expression for the temperature coefficient of photochemical reactions, and generally to attain to more specific ideas concerning the mechanism of chemical reactions. The prediction of the actual magnitude of any individual reaction velocity is not, however, yet possible, although some progress towards the solution of this problem is possible in the case of polymolecular reactions. T. H. P.

960. *Density, Dielectric Constant, and Refraction of Solid Salts.* **A. Heydweiller.** (Zeits. f. Physik, 3. 5. pp. 308–317, 1920.)—In 1914 E. Baumann (dissertation, Rostock) determined the density and dielectric constant of some powdered salts. The reduction of the values to the density of the compact salts by the Lorenz-Lorentz formula was unsatisfactory. This formula having been modified by E. Stoecker [see Abs. 716 (1921)], investigation of 27 salts has been resumed. Three of the salts, $BaCl_2$, $CuSO_4$, Na_2CO_3, have been studied, both anhydrous and hydrated. Assuming that the electric refraction (measured for wave-length 478 cm.) is represented by the sum of the refractions of the anhydrous molecule and the water of crystallisation, the three salts give the average value 6·3 (the values found for the three salts are 6·36, 6·22, 6·46) for the dielectric constant of 1 H_2O of crystallisation; the dielectric constant of water is hence strongly changed when the water is found in crystals. Accepting this value the dielectric constant of other salts may be estimated. Dispersion influences the optical refraction in two ways, being dependent upon the natural oscillation of the valency electrons in the ultra-violet (increasing the refraction) and the natural oscillations of the ions in the infra-red (decreasing it). In the absence of dispersion, the optical refraction is found to be equal to half the electric refraction for long waves, so that the two natural oscillations mentioned would have equal shares in the electric refraction, as Haber suggested. H. B.

961. *Separation of the Halogen Linkage.* **A. v. Weinberg.** (Zeits. f. Physik, 3. 5. pp. 337–342, 1920.)—Accepting the energy value of Franck, Knipping, and Krüger [Abs. 648 (1920)] for the dissociation of H_2 into atoms, $Q_{H_2} = 81 \cdot 3$ cals., the author has calculated the values $HCl = 119 \cdot 2$, $HBr = 76.3$, $HI = 59 \cdot 4$. Assuming further (Deutsch. Chem. Ges., Ber. 53. p. 1526 (1920) that the work to be done in splitting the linkage of the C-atoms in solid carbon is equal to the hypothetical heat of sublimation of C, he finds for the dissociation of the carbon compounds with Cl, Br, I respecting the Q 119·5, 74·2, 54·5. That is to say, the Q-values of the C- and H-links with the halogens, would be nearly the same or the linkages, halogen-carbon and halogen-hydrogen, would be equally strong, for mean temperatures. He now calculates the Q-values for the linkage between the alkali metals and the halogens after Born and Haber. For the dissociation of the gaseous NaCl, NaBr, NaI into atoms, he finds 132·6, 94·4, 77·6 cals., and for the K salts 135·7, 99·0, 81·7, that is, larger figures than for the compounds of the halogens with C and H, as was chemically to be expected. As regards the dissociation of the same alkali halides into ions and the electronic affinities, his figures confirm Born, not Fajans and Herzberg. Chlorine seems to have the same affinity for C, H, and the electrons; this does not hold for bromine and iodine. The dissociation of $ZnCl_2$ into atoms requires 214·3 cals. H. B.

962. *Atomic Refraction.* **W. Swientoslawski.** (Am. Chem. Soc., J. 42. pp. 1945–1951, Oct., 1920.)—In 1911, Eisenlohr published revised calculations of the refractivities of carbon, hydrogen, and other atoms in organic compounds, which, however, do not differ from those of Brühl owing to the assumption made by each author that the molecular refractions of the organic compounds employed are equal to the sums of the refractions of the separate atoms, $M_D = \Sigma A_D$. On this supposition, the computation of atomic refraction depends on the average value of the refraction of the CH_2 group and those of certain atoms. If, however, the individual atomic refractions show even small deviations, this method cannot be used. To determine the limits of variations in the refractions caused by carbon and hydrogen atoms in the compounds which contain only the linkings C—C and C—H, the author has employed the following method: The refractions for the D lines of C, H, and CH_2 being denoted by r_C, r_H, and r_{CH_2}, the molecular refraction, M_D, of the hydrocarbon C_nH_m is expressed by—

$$M_D = nr_{CH_2} + (m - 2n)r_H + \Sigma\Delta r_C + \Sigma\Delta r_H$$

or

$$M_D = nr_{CH_2} + (m - 2n)r_H + \Sigma\Delta r,$$

where

$$\Sigma\Delta r = \Sigma\Delta r_C + \Sigma\Delta r_H.$$

This equation cannot be solved when the increments $\Sigma\Delta r$ are not known, and the quantities r_C and r_H can be computed only by reference to several chosen compounds, thus obtaining the average values of r_C and r_H on the supposition that $\Sigma\Delta r = 0$. In some cases it is more advantageous to use the quantities r_{C-C} and r_{C-H}, corresponding to refractions of the atomic linkings C—C and C—H, especially when it is desirable to compare these quantities with the thermochemical data. It is clear that the quantities r_{C-C} and r_{C-H} can be computed when r_C and r_H are known, for $r_{C-C} = 0\cdot5\,r_C$, and $r_{C-H} = r_H + 0\cdot25\,r_C$. As a basis of calculation the compounds, *n*-pentane, 2-methyl-butane, *n*-hexane, *n*-octane, di-isobutyl, di-iso-amyl, cyclopentane, and cyclohexane, were selected. Tables are given of the values of the molecular refractions, of the equations connecting r_{CH_2}, r_H, and $\Sigma\Delta r$, and of a comparison between observed and calculated values of M_D, whereby Δr is seen to be very small, so that the atomic refractions remain constant in the 8 compounds within ± 0·07 %. To explain why Eisenlohr's calculations show a sufficient agreement with the direct measurements, the value of M_D is discussed: this consists of two terms, $M_D = nr_{CH_2} + \Sigma r_X$, of which nr_{CH_2} is very large, while Σr_X corresponding to the refraction of other atoms or groups in the molecule is always small. In consequence, small errors in the determination of the values of r_C and r_H, etc., do not exert any marked influence on the calculated values of M_D. To show that the refraction of carbon and hydrogen depends on the constitution of the hydrocarbons, the observed values of M_D are given for several compounds and compared with those calculated from the formula, $M_D = \Sigma r_C + \Sigma r_H$. The conclusion is drawn that the refraction of carbon and hydrogen in the eight selected compounds is not identical with that in the methylenic polymethylene hydrocarbons, the introduction of the CH_2 group producing a small, but appreciable increase, Δr, in the molecular refraction. In a subsequent paper it will be shown that the methyl group exerts a similar effect upon the heat of formation of the atomic linkings C—C and C—H. In the case of compounds which contain other atoms in the molecule (*e.g.*, oxygen), the author's results differ from Eisenlohr's, and the differences are found to be greater, the larger the value of Σr_X in $M_D = nr_{CH_2} + \Sigma r_X$, where nr_{CH_2} corresponds to the refraction of the CH_2 group and Σr_X to that of the rest of the molecule. Data are given for a number of aldehydes and ketones. Deviations are accounted for by supposing the refraction of the — CO group, or of the oxygen, to be variable and depend on the constitution of the molecule. Eisenlohr's data are not in agreement with the above, and the object of this paper is attained by showing that the exact determination of the refractions r_C and r_H is indispensable in all calculations concerning atomic refraction.

H. H. Ho.

963. *Hydrogen-Ion Concentration in Pure Water by Measurement of E.M.F. of Concentration Cells of High Resistance.* **H. T. Beans** and **E. T. Oakes.** (Am. Chem. Soc., J. 42. pp. 2116–2131, Nov., 1920.)—The e.m.f. of concentration cells of very high internal resistance can be measured by using them to charge a condenser and then discharging it through a ballistic galvanometer. By this method the hydrogen-ion concentration of impure water was found to be $1\cdot23 \times 10^{-8}$ or $10^{-7\cdot91}$, *i.e.*, about one-tenth of the value usually deduced from measurements made with solutions of various kinds instead of with pure water. This low value was only obtained when very great care was taken to exclude all traces of acid; a very slight relaxation of the precautious raised the value tenfold, *e.g.*, to the figure commonly accepted for this constant. The time required to charge the condenser was usually from 2 to 10 minutes, and about an hour was required to secure steady readings with the hydrogen electrode. T. M. L.

964. *Saturated Potassium Chloride Calomel Cell.* **H. A. Fales** and **W. A. Mudge.** (Am. Chem. Soc., J. 42. pp. 2434–2453, Dec., 1920.)—The e.m.f. of the combination—

Hg, HgCl | KCl (sat.) || KCl (sat.) | 0·1 *N*—HCl | H_2 (Pt)

has been measured for the temperature range 5–60°, at intervals of 5 deg. Taking the value of the normal calomel cell at 25° as 0·5648 volt, that of the saturated potassium chloride calomel cell at 25° is 0·5266 volt; its temperature coefficient is + 0·000 20 volt per degree rise in temperature for temperatures within the interval 5°–60°. The e.m.f. of the system—

Hg, HgCl | *xN*—KCl || KCl (sat.) || 0·1 *N*—HCl | H_2 (Pt)

and the value of the electrode potential, Hg, HgCl | *xN*—KCl, in the above system at 25° have been computed for values of *x* ranging from 0·1 *N* to saturation (4·12 *N*). The e.m.f.'s of the combinations—

Hg, HgCl | 0·1 *N*—KCl || KCl (sat.) || KCl (sat.) | HgCl, Hg,
Hg, HgCl | 1·0 *N*—KCl || KCl (sat.) || KCl (sat.) | HgCl, Hg,
Hg, HgCl | 0·1 *N*—KCl || KCl (sat.) || 1·0 *N*—KCl | HgCl, Hg,
Hg, HgCl | 0·1 *N*—KCl || KCl (sat.) || 0·1 *N*—HCl | H_2 (Pt),

and Hg, HgCl | 1·0 *N*—KCl || KCl (sat.) || 0·1 *N*—HCl | H_2 (Pt), have been measured for the temperature range 25–40° at intervals of 5°, and it has been found that these combinations are quite unreliable above 25°, and reliable at 25° only for about a week.

It appears that the decrease in the e.m.f. of the 0·1 *N*- and *N*-potassium chloride calomel cells, when used in conjunction with a saturated salt bridge, is due to the diffusion of the concentrated potassium chloride solution from the bridge into the cell and not to the formation of a complex ion as a result of the interaction of the calomel and the potassium chloride solution.

In preparing new calomel cells it is necessary to use all new materials and not merely to replace the potassium chloride solution. The saturated potassium chloride calomel cell is the best cell for use in conjunction with a saturated salt bridge, because it has a very low temperature-coefficient, can be used safely at temperatures from 5° to 60° and may be relied on for its constancy over long periods of time. T. H. P.

965. *Electrolytic Preparation of Sodium Permanganate.* **C. O. Henke** and **O. W. Brown.** (J. Phys. Chem. 24, pp. 608–616, Nov., 1920.)—Sodium permanganate can be prepared by electrolytic oxidation of a manganese anode in contact with a solution of sodium hydroxide. Particularly good results are obtained when lime is added, as this gives a precipitate on the kathode, which appears to act as a membrane or diaphragm to prevent electrolytic reduction of the permanganate at the kathode. The yield reaches a maximum at a current-density of 13 amps./cm.^{2} and increases progressively as the temperature falls from 60° to 8° C.; but it passes through a minimum at a concentration of 65 gm. per litre, the efficiency rising to higher values especially on diminishing the concentration. The highest yield recorded was over 38 %. T. M. L.

966. *Hydrogen Overvoltage; Criticism of the Papers by MacInnes, Adler, and Contieri; Reply by MacInnes.* **E. Newbery.** (Am. Chem. Soc., J. 42. pp. 2007–2011, Oct., 1920.)—In a criticism of papers by MacInnes, Adler, and Contieri [see Abs. 359, also 973 and 1447 (1919)], in which overvoltage is attributed mainly to surface-tension forces in the formation of bubbles of gas, it is pointed out that in measurements of overvoltage made by these authors, the factor of transfer resistance has been neglected, the p.d. between electrode and electrolyte during electrolysis having been measured. This value is influenced by the resistance of an intervening film of gas. It is considered by the present author that a gas film of molecular dimensions is at first evenly deposited on the surface. The formation of bubbles is then considered to arise from the gradual creeping together of the surface gas, a process which is affected by surface conditions but has no influence on the overvoltage. In support of this view, it is found that external pressure has no appreciable influence on the true overvoltage. The variation of overvoltage in stages according to the different states of valence of the metal kathode is reiterated. The observed phenomena support the theory that overvoltage is due to the intermediate formation of unstable hydrides at the kathode and higher oxides at the anode.

D. A. MacInnes (*ibid.*, pp. 2233–2238, Nov., 1920).—It is pointed out that Newbery restricts the definition of overvoltage to the phenomenon of counter-e.m.f., whereas in the paper of MacInnes, Adler, and Contieri criticised by Newbery, overvoltage is held to include transfer resistance together with counter-e.m.f. The statement of Newbery that high transfer resistances may obtain at low current-densities is considered to be untenable. The overvoltage is held by MacInnes to be larger than the counter-e.m.f. and the difference between the quantities is considered to be a potential and not a resistance. It is considered that hydrogen overvoltage is due primarily to a layer of supersaturated dissolved hydrogen in the electrolyte surrounding the electrodes. The possible formation of unstable hydrides assumed by Newbery is regarded as a consequence of, and in no way an explanation of, overvoltage. The oscillograph work of Le Blanc which demonstrates that with an electrode at which hydrogen is evolved, the potential drops rapidly after the exciting current is disconnected, is considered to support this view and to be incapable of reconciling with the assumption of the formation of hydrides. It is pointed out that, with different metals, the counter-e.m.f. measured by Newbery is approximately equal to the single p.d. of the metal in a normal solution, thus supporting the view that the potentials measured are determined by the formation of ions by the metals themselves rather than being due to the decomposition of unstable hydrides. J. N. P.